

Three Paces Beyond the Horizon

Outstanding Soviet Scientists



Edited by V. LYSENKO

Три шага за горизонт

Под редакцией В. М. Лысенко

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by G. G. Egorov

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Part I

Foresight

Chapter I.1

EXTRACTS FROM AN AUTOBIOGRAPHY

Konstantin Eduardovich Tsiolkovsky was a remarkable man, a man 'far in advance of his time' Academician Sergei Korolev said, a man who enriched his country and mankind with a host of brilliant ideas. He not only contributed to aeronautics, aviation, aerodynamics, astronomy, geology and biology, he was also a philosopher and a man of letters. He developed a theory of space flight and is irrefutably the founder of rocket dynamics and cosmonautics. He was indeed a prophet.

People will not remain on Earth forever. In striving for light and space they will first timidly penetrate into what lies outside the atmosphere and will then conquer the whole of the Solar system. Heroes and daredevils will forge the first highways between the Earth and the Moon, the Earth and Mars and later there will be the Moscow-Moon route, and the Kaluga-Mars route.

I bequeath all my publications on aviation, rocket flight and interplanetary communications to the Bolshevik Party and to the Soviets—the true guides to the progress of human culture. I am convinced that they will successfully accomplish these endeavours.

K.E. Tsiolkovsky

His writings include a number of autobiographical notes, some of which he wrote in January 1935, a few months before he passed away. Below we present some extracts from his notes.

By nature and disposition I am a revolutionary and a communist, to which my paper *Woe and Genius* amply testify. It was published in 1916, when the Czar was still

in power. In the paper I propounded the advantages of communes in the broad sense of the term.

Why then did I not make an active revolutionary?

There were several reasons, namely:

1. At the age of ten I became deaf. This made me a weakling and an outcast.

2. Being handicapped, I was deprived of friends and social connections.

3. For the same reason I was ignorant of life and was materially helpless.

My reformist instincts led me to but one thing, an interest in technology, science, invention, and natural philosophy. At first it all lay within the realm of day-dreaming; but when my innovations began to acquire a more coherent expression the self-righteous orthodox scientists and I found ourselves at different poles. I was regarded as an upstart, a reformist, and was thus not recognized.

My biography quite naturally consists of trifles and work. The latter reigned supreme over everything that was trivial and commonplace. Moreover, because of the limitations of everyday impressions, my life-story cannot have the colour typical of the biographies of people who are normal and have no physical defects.

If we follow the progress of mankind, we seldom see the impact of heredity. All the Faradays, Edisons, Fords, Columbuses, Watts, Stephensons, Newtons, Laplaces, Franklins and so on came from the people; they had no talented ancestors in the background. In cases like these, there seems to be no trace of heredity at all. It may well be said then that genius is the product of a milieu rather than what is inherited from parents or passed down from other more distant relatives. The natural gifts with which our progenitors might have been endowed presumably did not find any world-wide expression, as they were confined to a much narrower scope.

It is only in exceptionally rare cases that talent is inherited. Thus, the sons of Herschel and Darwin did become famous, though not as celebrated as their fathers. There are few such examples in the history of science. In most cases it is just the opposite.

My father was invariably cool, reserved, and had never quarrelled with my mother. Only once in my life did I

witness a disagreement. My mother started it, but father made no reply to her rude remarks. Instead, he determined to divorce her. It all ended by her begging him to forgive her. This was around 1866, and I was nine years old. Those who knew my father regarded him as a man of intellect and a good speaker. Among the bureaucrats he was known as a Red, whose impeccable probity made him quite intolerant.

Was my father educated? By the then existing standard he knew no less than the others of his circle, though as someone with humble origins he did not know much about foreign languages, and could only read Polish newspapers. Although in his youth he was an atheist, as he grew older, he and my sister sometimes attended Mass in a Catholic Church. However, he had nothing to do with the clergy and I never saw either a Catholic or an Orthodox priest in our house.

My mother's temperament was quite different. She was of sanguine disposition, always ready to laugh and tease, while remaining proud and talented. The predominant trait in father's character was will-power; with mother it was talent. What I particularly liked was her singing. My father's calm nature acted as a counter-balance to my mother's impetuosity and light-mindedness.

What were then the features of my parents that had moulded my own character? I think that I was vouchsafed a combination of my father's strong will-power and my mother's talent. My brothers and sisters did not turn out the same because they were fortunate not to have been handicapped. As for me, all my life I was humiliated by deafness, a precarious existence and dissatisfaction. These misfortunes caused me to be more determined, to work, and to continue my quest.

I look back now as if it has all been a dream in which a giant took me by the hand and led me downstairs into a garden, with me glancing at him in trepidation. I think that the giant was my father.

I was an ardent reader and read all that I could get hold of.

I was fond of day-dreaming and even paid my little brother for listening to all my nonsense. We were little children and I wanted everything to be little too: houses,

people and animals. Then I started wanting to be physically strong. In my thoughts I could jump high and climb up ropes and poles with feline dexterity. I imagined a complete absence of gravity.

I liked to climb fences, roofs and trees, and jumped off the fence wishing that I could fly. I also did a lot of running about, played hide-and-seek, ball games (which included a Russian one called 'lapta' in which a ball is hit as in base-ball), and 'gorodki' (a kind of skittles). I used to fly a kite on a string to which a box with a cockroach was attached.

This was the period of my normal life before I became deaf (which was at the age of ten). My life did not differ very much from the one of other children. This is exactly my point about the first part of my story. What can be inferred from it is interesting, though by no means new—it is impossible to guess in which field of human activity a person may find himself successful.

We are inclined to embroider the childhood of great people, and since we are biased, the record is exaggerated.

One day at the beginning of winter, when I was ten or eleven, I went sledging. I caught cold, after which I contracted scarlet fever. Throughout my illness I was delirious and it was thought I would not recover. However, I did get well, though I became absolutely deaf with no prospect that my malady could ever be alleviated.

Deafness made my ensuing life less interesting since it deprived me of contact with other people, and the ability to observe and deduce. It is the biography of a cripple, exceptional only in the sense that there is a dearth of characters and conflicts. I shall recount what conversations I had and describe my rather rare relations with other people, though neither can be exhaustive nor exact. There were times when I could hear better, and it is these moments that I remember.

When I was still a little boy though after I became deaf, I discovered in one of my reading books the distance to the Sun. I was so surprised I told everybody about it.

We used to play dominoes and cards. I used to like games but now I cannot feel anything but repulsion when I see playing cards, draughts, chess, or any such games.

It is quite natural that we could not afford to have any nannies or governesses at home. My immediate relatives sympathized, but could do nothing. My mother died, and my father became wholly absorbed in providing for the family, while my aunt was both illiterate and incapacitated.

This three-year period was one of clouded perceptions and the saddest and darkest time of my life. As I write I am trying to remember the events of those days, but I can't recall anything. All those years have vanished and I cannot recall anything but skating in the streets and sledging.

Once I saw a lathe and started making my own one. I succeeded and used it to sharpen wood, disregarding the pessimism of my father's friends. In the wake of several windmills I made a cart with a windmill, which could move against the wind and in any direction. This was when even my father was startled and began to think highly of me. After that there followed a musical instrument with a single string, keyboard and a short bow that moved quickly along the string. It was set in motion by wheels, which in turn were driven by a pedal. I even wanted to construct a big wind-driven cart for driving in (on the basis of the model). I began to work on it but had to drop it altogether when I realized that wind had too little power and was too inconstant.

All these toys I made myself and produced without any books on science and technology.

The first signs of a serious intellectual consciousness appeared when I began to read. When I was about fourteen I read a textbook on arithmetic and found it quite clear. From that time on I realized that books were accessible to me and that there was nothing sophisticated about them. It was with curiosity and understanding that I had rummaged through my father's books on natural science and mathematics (for some time my father had taught these subjects). I suddenly became curious about astrolabes, instruments once used to measure distances to inaccessible objects, about mapping, and measuring altitudes. I installed an altimeter and used astrolabe techniques to estimate the distance to the fireman's watch-tower without leaving my house. I found it to be 400 archins (1 archin = 27.95 inches) away. I checked

the distance and there was no mistake. That was how I began to trust theoretical knowledge.

My father realized that I was technically-minded and I was sent to Moscow. But what could a deaf person do there? What connections could I establish? Without any experience I could no more than grope my way to a career and fortune. I received between ten and fifteen roubles a month from home, but I could not afford to buy even tea or potatoes, so I survived entirely on rye bread. However, I did buy books, tubes, mercury, sulphuric acid and other things.

I remember very distinctly that there was nothing else but rye bread and water. Once every three days I used to go to the baker's to buy nine kopeks-worth of bread. Thus, my monthly expenses on food amounted to 90 kopeks.

My aunt knitted a whole pile of socks for me and sent them to Moscow. However, I decided that I could do without them (how wrong I was!). I sold them at the lowest price imaginable and bought alcohol, zinc, sulphuric acid and some other things. It was mainly because of the acids that my trousers were marked with yellow spots and had holes in them. The boys in the street would see this and shout: "Have the mice been gnawing at your trousers?". I wore long hair, but only because I had no time to cut it. I think I must have looked very funny, but my ideas made me really happy and rye bread did not discourage me in the least. It did not even occur to me that I was starving and becoming emaciated. What then did I do in Moscow? Did I actually confine myself entirely to those feeble attempts to carry out physical and chemical experiments?

In my first year, I painstakingly and systematically covered the course in elementary mathematics and physics. On many occasions, after reading some theorem, I found the proof myself. It was much easier and more pleasant for me to do it on my own rather than to read through the printed explanation. Although I was not always successful, my inclination to think independently was quite evident.

In the second year I took up higher mathematics. I covered the course in higher algebra, differential and integral calculus, analytical geometry, solid trigonometry and other subjects. But I was engrossed in a number of

questions which I tried to answer by immediately applying the knowledge that I had acquired. I was thereby covering analytical mechanics practically on my own. The problems I was interested in and solved were:

1. Would it be possible to use the energy of the Earth's motion for practical purposes? My answer was correct: No.

2. What form does the surface of a liquid acquire in a vessel that rotates about a vertical axis? My answer was: a paraboloid of revolution. Since telescopic mirrors required this shape, I dreamt of making gigantic telescopes with moving mirrors made of mercury.

3. Would it be possible to get a train to run around the equator in which no gravity would be counteracted by centrifugal force? My answer was: No. Air resistance and other factors interfere.

4. Would it be possible to build metal balloons that would not let gas out, thus causing them to soar into the air? My answer was positive.

5. Would it be possible to utilize the exhaust steam from high-pressure steam engines? My answer was in the affirmative.

Undoubtedly, many questions cropped up and were solved before I could master higher mathematics. Moreover, they had been solved by others long before.

6. Would it be possible to apply centrifugal force to send objects beyond the atmosphere into outer space? I did invent such a machine. It consisted of a closed chamber or box, within which two rigid elastic pendulums, with spheres at the upper vibrating ends, were made to oscillate upside down. The spheres travel in arcs, while the centrifugal force should lift the cabin and carry it into space. My invention thrilled me so much that I could not keep still and went out into the street to quench my overwhelming joy. I walked the streets of Moscow for an hour or two, deep in thought, and verifying in my mind what I had discovered. But, alas! when I was still outside I realized that I had misled myself. The machine would only joggle up and down, and its weight would not be reduced by a gramme. However, that ephemeral delight was so intoxicating that all my life I have seen my device in dreams, with me flying in it in a state of ecstasy.

My landlady did the washing for the family of a well-known millionaire Ts. She mentioned my name there, and Ts's daughter became interested with me. We wrote letters to each other for a long time, until our correspondence ceased due to circumstances over which we had no control.

What is really interesting is that in one of my letters to her I tried to convince her that there had never been a greater man than myself and that there would be no one like me in the future. She even laughed at it in her reply. Now I cannot think of the letter without blushing. But what self-assurance! To be absolutely frank, I did think of conquering the Universe even in my early days. What comes readily to my mind is the apophthegm that only a bad soldier does not hope to become a general. However, many ambitious people have lived without leaving a trace after they were gone.

Now quite the opposite, I worry whether I have earned the bread I have eaten these past seventy-seven years? That is why all my life I have wanted to work on land and literally eat my own bread. What prevented me was my ignorance of life.

What did I read in Moscow, and what interested me most of all? First and foremost, there were the exact sciences. I avoided any kind of uncertainty and 'philosophy'.

The famous young writer Pisarev made me tremble with delight and happiness. In him I saw my *alter ego*.

Just after Christmas 1880 I at last received news that I had been appointed a teacher of arithmetic and geometry at a district school in Borovsk.

The local people directed me to a house which belonged to a widower and his daughter. It was situated in the suburbs near the river. I was allotted two rooms for myself and provided with a meal of soup and gruel. I was quite satisfied with what I had and I stayed there for a long time. My landlord was a wonderful person, though a heavy drinker.

At tea-time and during lunch and supper I often talked with his daughter. Her understanding of the Gospel surprised me very much.

It was time for me to get married and I took her for my wife without actually loving her, but hoping that this

kind of wife would not keep me under her thumb, that she would work herself and would not prevent me from doing the same. My expectations were not betrayed.

On our wedding day we walked the four miles to the church. We did not dress specially for the occasion nor did we allow anyone to see the ceremony. We returned home, and no one actually knew we had been married.

Before my marriage and after it I knew no other woman but my wife.

I feel embarrassed when I write about such intimate things, but I am no humbug and do not wish to conceal either the bad or the good aspects of my life.

I looked on marriage as having only a practical value for I discarded all the theoretical irrationalities of religion when I was still only sixteen.

On my wedding day I bought a lathe from my neighbour and started cutting glass for electrical machines. The news of my wedding did somehow reach the ears of some musicians and it took me some effort to drive them away. The only one who got drunk was the priest who had officiated at the ceremony, and I hardly need mention that it was not me but the landlord whose hospitality the clergyman shared.

I have never acted as host, neither that I ever been fond of visiting people. The salary I received enabled us to buy very simple and poor clothes. But there was no question of either starving or wearing something that was patched up.

When it came to quarrels and family disputes, I always took the blame upon myself and asked to be forgiven. That was how peace was restored. However, it was my work that dominated my life. I wrote, calculated, soldered, planed, welded and did many other things. I used to make fairly good piston air pumps and steam engines and I carried out various experiments. When someone dropped in and asked me to show him my steam-engine, I would usually agree to do it if my guest chopped the wood to feed the boiler.

When I was thirty-two or thirty-three, I became interested in air resistance. Then I started to calculate, and discovered that Newton's result pertaining to wind pressure on an inclined plane was erroneous. I also arrived at some other conclusions that were less known at that

time. I remember how during the Christmas holidays I incessantly worked for about two weeks before I felt so giddy that I had to run out of the house to skate on ice.

Ever since I arrived in Borovsk I had been working assiduously on the theory of the airship. I continued to work during the school-holidays and I did not celebrate the feast days. Even now, I go on working for as long as my health permits me.

In 1887 I became acquainted with one Golubitsky. At that time, the famous Sophie Kovalevskaya—the professor of mathematics in Sweden, who died some time ago—was visiting him. He came to Borovsk and asked me to go with him to meet his guest, who was eager to make my acquaintance. An unsociability caused by my infirmity did not allow me to accept the invitation. Thus, I did not go, which was presumably for the best.

Golubitsky suggested I go to Moscow, to meet Stoletov (one of our celebrated scientists) and make a public report on my airship. I wandered the streets of Moscow for some time before I found the professor's house. From there I went to the Polytechnical Museum to make my report. Instead of reading out the manuscript, I only gave a brief account of the most essential points in my work. No one objected.

On late evening I was returning home from an acquaintance. It was on the eve of the eclipse in 1887 and there was a well beside the road and something was glistening near it. I went closer and for the first time in my life saw pieces of rotten wood sparkling brightly. I took as many of them as I could and went home. I broke the pieces into small bits and scattered them all round my room. In the darkness the impression was that of a starry sky. I asked everyone I could find to come and enjoy the sight. In the morning there was to be the eclipse, which is exactly what happened. However, it started to rain. I went to look for my umbrella to go back outside, but it was nowhere to be found. Then I remembered that I had left it near the well. Thus, I had lost a new umbrella. But what I had obtained instead were the pieces of rotten wood and the starry sky.

When I didn't read or write, I used to walk. I have never been inactive.

When I was not busy, particularly during my walks, I

always sang. My bird-like songs never had any words as they would have revealed my thoughts, which I did not want. I sang in the morning and at night. This was how my mind had its rest. The tunes depended on my mood, which was influenced by emotions, impressions, nature itself and often by reading. Even now, when my voice has become hoarse, and the tunes do not differ very much, I sing practically every morning and before going to bed. My singing was not meant for anyone else and nobody heard me. I do it only for my own amusement, and I am afraid I can't do without it.

The Assonov family was well-known in our town. Assonov helped me get in touch with the amateur physics club in Nizhni Novgorod (now called Gorky). Its chairman was S.V. Shcherbakov, who has recently died in Kaluga. At first with the help of the club and then on my own I started publishing papers on the Sun, flying devices and other things in periodicals such as *Nauka i zhizn* (Science and Life), *Nauchnoye obozreniye* (Scientific Review), *Vestnik opytnoi fiziki* (The Bulletin of Experimental Physics), and *Vokrug sveta* (Round the World). Theoretical research by some professors indicated that some of the best shapes would encounter extremely great aerodynamic resistance. To refute these objections, I carried out a large number of experiments on the resistance of air and water. I installed the instruments myself. At first they were small, but later they were so large that they occupied practically the whole of my drawing-room. The door would be locked to prevent anyone entering the room and disturbing air currents. The postman would often find himself waiting until the observation ended and someone opened the door. He would hear the beat of the metronome and the numbers 15, 14, 15, 15, 14 and so on. At long last he would be let in grumbling. One of our relatives, on seeing the monster (my apparatus) in our rooms, asked my wife: "When is he going to get that devil away?" A priest also remarked that the corner where the icons hung was dirty.

And now about our children. They all studied at secondary schools. The three daughters were educated at the gymnasium, and my eldest daughter studied at the higher courses. The boys were good pupils, except Vanya whose health was poor ever since he was born. However, he did

manage to complete the course in book-keeping. One son died when he was a student, while the other could not cope with his precarious condition in the capital, and following my example, passed his examinations as an external student, later being employed as a teacher at an elementary school. Soon, however, he too has died. Now I only have two daughters, who stay together with me here in this house. Six grandchildren stay here, the seventh stays in Moscow with his father. He used to live here practically all the time, but now he only comes to visit me in summer.

I continued my studies in electricity, both static and galvanic. I made all kinds of machines, and even some very complicated ones, such as an inductive device with two revolving Wimshurst wheels. At one time when any of my few acquaintances dropped in, they were lavishly treated to an electrical performance, and they would leave my house feeling as though they had had sumptuous dinner. Nowadays, I have no personal contacts and only receive people on business or when some scientific subject is to be discussed. I cannot stand wasting time on idle talk any more.

My research was published in various journals, but remained unheeded. It was only in my heart that they left a trace and they alone caused me to strive to soar ever higher.

My scientific study of a jet spaceship only came to public notice when it was published for the second time between 1911 and 1912 in the well-known and widely circulated rich metropolitan periodical *Vestnik vozdukhoplavaniya* (Bulletin of Aeronautics). Many scientists and engineers (outside Russia) then claimed priority over the topic. However, they were unaware of my first publication in 1903 and hence their claims were proved to be unjustified. The fact that my 1903 paper was unknown saved my priority. It was exactly so with D. Mendeleev and many others.

The Revolution received a triumphant welcome. People looked forward to the end of war and the coming of freedom. Since I was no longer young, my attitude to the events was quite reserved. I did not attach any importance to trinkets and never wore red ribbons. That was why in one school where I gave classes they thought I

was a reactionary. However, I showed them the book I published during the czarist regime. It was purely communist in orientation. In the girls' school for the daughters of the clergy I was called a Bolshevik and was more cold-shouldered than before. My apparent support for the revolution was not favourably received.

The basis of my natural philosophy was the complete rejection of routine. What came instead was the understanding of the Universe as it is rendered by contemporary science. The science of the future will, of course, surpass the science of today, but so far even the current state of science proves to be a reliable and even the only source of philosophy. Science, observation, experimentation and mathematics are the basis of my own philosophy.

Under the Soviet Government and with a pension, I could freely give myself away to my research. Once hardly noticed, I have now excited interest in my work. My airship is acknowledged as a significant invention, and various research centres have been organized to study jet propulsion. A large number of articles on my research and achievements have begun to appear in newspapers and periodicals. My seventieth birthday was celebrated by the Press, and five years later my anniversary was celebrated in Kaluga and Moscow as a special occasion. I have been awarded the Order of the Red Banner of Labour. My pension has been increased.

The Soviet Union is decisively and perseveringly marching on its great path to Communism and the industrialization of the country, and my heart cannot but beat wholly in accord with this movement.

In the Old Little House on the Oka River

There are many memorable places in Kaluga that are named after Tsiolkovsky. This is the town where he lived for more than forty years and whose honorary first citizen he became. A remarkable place which should certainly be mentioned is the Order of the Red Banner of Labour State Museum of the History of Cosmonautics and its memorial section—the house where Tsiolkovsky lived. The director and curator of the museum is the scientist's grandson, A.V. Kostin (who holds the title Honoured Worker of

Culture of the RSFSR, and who has been awarded the K.E. Tsiolkovsky, S.P. Korolev, and Yu.A. Gagarin medals and diplomas). On the eve of Tsiolkovsky's jubilee A. Kostin spoke of the latest projects and finds associated with Tsiolkovsky. In part, KOSTIN said:

Each exhibit in the little house on the Oka river has its own history. Almost all the pieces illustrate a laborious or gruelling experience.

In his autobiographical notes, Tsiolkovsky frequently mentioned that he was never interested in his family's history. He did know that one of his ancestors was the well-known rebel Severin Nalivaiko, who was executed in Warsaw. Although not everything is clear, the Tsiolkovsky and Nalivaiko families did come into contact at one time in a small Ukrainian town, and perhaps they became related.

The archives allow us to trace the Tsiolkovsky family tree back to the end of the seventeenth century. The first ancestor to be mentioned in these documents is Jacob Tsiolkovsky, a nobleman who took part in the session of the Sejm when August II was elected King of Poland in 1697. Jacob's son Valentin was the owner of the estate Velikoye Tsiolkovo. His son Felitsian had a son Foma, the father of Ignati, who had several sons, one of whom was Konstantin Tsiolkovsky's father.

Konstantin Tsiolkovsky could not have the faintest idea that he had such an eminent pedigree, to say nothing of its own coat of arms. The latter, however, did not save the family from losing its prestige and becoming more impoverished with every generation. The estate was sold and Tsiolkovsky's immediate relatives moved to the Ukraine, where they had never risen beyond the rank of petty clerks at court. Worries about day-to-day life completely overshadowed memories of a coat of arms.

When we came across the description of the coat of arms in the archives, we asked M.N. Efremov, an architect and a devoted friend of our museum, to reproduce it.

The reproduction contains an interesting symbol. The coat of arms is crowned with a bird, and we are told that as a boy Konstantin Tsiolkovsky was called a 'bird' for his constant desire to jump and fly. Against a blue background there is a horse-shoe—the symbol of success,

happiness and a knight's visor. Wasn't Tsiolkovsky himself a chevalier of science?

Several letters were found in Kharkov, and Z. Khodov, a young philosopher, brought them and some postcards that had been sent to him by Tsiolkovsky from Kaluga across all the front-line roads.

One day an old man from Moscow came to the museum. He placed on the table two heavily thumbed booklets that had been published in Kaluga. When in December 1941, the town was being liberated from the German fascists, he was one of the soldiers detailed to clean up the museum from the invaders' damage. He found the books in the litter and kept them for the better part of forty years.

Yuri Gagarin first came to Kaluga two months after his legendary flight. He arrived there to lay the first brick of the foundation for the K.E. Tsiolkovsky Museum of the History of Cosmonautics.

The first space-pilot laid flowers on the grave of the founder of cosmonautics and spoke at a meeting in the town. He met the scientist's relatives, but was unable to visit the little house, as he had to be in Moscow the same day and, hence, in Zvezdny (where he lived) by the evening. He was very sorry not to have had the opportunity to visit the unique house, but promised to do so in his free time.

He availed himself of the earliest opportunity, and after he had seen all the exhibits, he sat at the table to put down his impressions in the guest book. On the table just beneath Tsiolkovsky's own wall clock stood the clock that Gagarin commissioned from the Serdobsrk clock factory especially for the museum. Gagarin was moved to see his gift had been placed next to that of his master. The last words in the entry read: "For us, cosmonauts, Tsiolkovsky's prophetic words on the conquest of space will always be directives and will always inspire us to go forward!"

Today this clock is the most valuable gift the museum has received.

A hand-written document which the museum received some time ago is worth mentioning. It is a letter from Tsiolkovsky to the Railway administration concerning the dismissal of a remote relative who had been a station

master in the Moscow region, and from whom he had learned the facts about the case. In spite of his usual modesty he concluded his letter with: "K. Tsiolkovsky, holder of the Order of the Red Banner of Labour. Our address is: Kaluga, No. 1, Tsiolkovsky Street. Telephone 6-42".

Interesting finds are sometimes discovered in the museum's archives. Thus, a copy of *Research of the World's Spaces by Jet Devices*, the impression of which came out in 1926, was found to contain the author's editorial corrections. It should be mentioned that although this fundamental paper on cosmonautics outlining the gradual conquest of space was written at the end of the nineteenth century, it was greatly valued by Academician Korolev, who considered it to be the most precious book in his library.

A pile of czarist banknotes was once found in a book Tsiolkovsky had been given before the Revolution by the popularizer of his research Ya.I. Perelman. This was how Tsiolkovsky kept his scanty savings to pay for the publication of his works, often to the detriment of his family.

Chapter I.2

LIFE MUST BE LIVED WITH ENTHUSIASM

On the life and deeds of Yuri Kondratyuk—a pioneer of Soviet cosmonautics

His deeds, initiative, and talent made him
a coruscant personality...

Academician V.P. Glushko

Today we can see the pictures of this man at the State Museum of the History of Cosmonautics, the Polytechnical Museum, and the "Kosmos" pavilion at the All-Union Exhibition of National Economic Achievements side by side with those of K.E. Tsiolkovsky. His image can be found on various medals, badges and even on postal envelopes. In the Great Soviet Encyclopaedia a long article is allotted to 'a pioneer of cosmonautics'. Streets in Moscow, Kiev, Poltava, Kamen'-on-the Ob, Rubtsovsk, and Malaya Viska in the Ukraine, as well

as the Oktyabrskaya stanitsa in Kuban, and a square in Novosibirsk have been named after Yuri Vasilievich Kondratyuk. In 1967 Soviet scientists asked the International Association of Astronautics to call one of the craters on the far side of the Moon the Kondratyuk crater. If we take a look at a globe of the Moon, we shall see his name next to those of N.E. Zhukovsky, S.P. Korolev, I.V. Kurchatov, G.Ya. Bakhchivandzhi, and Yu.A. Gagarin. Nowadays it is quite easy in the USSR to find out about the life and work of Yu.V. Kondratyuk, you need only go to museums in Moscow or the Institute of the History of Natural Sciences and Technology of the USSR Academy of Sciences. But I would like to tell my readers what people remember about this self-taught scientist and what I have discovered in various museums. It is needless to say that the priority in such explorations belongs to those who have worked before me.

This Has Become My Aim

From Yu.V. KONDRATYUK'S letter to K.E. Tsiolkovsky (1929):

"Thank you very much for the books you have sent me. I was extremely surprised to realize how consistently and accurately I repeated not only most of your research on interplanetary communications, but also your work of a general philosophical nature.

It would seem that this is not just coincidence, but the fact that my way of thinking is directed along the same lines as yours.

I have been working on interplanetary communications for twelve years. I began my research at sixteen when I became convinced that space flight was feasible, and the attainment of this goal has been the sole aim of my life."

From Yu.V. KONDRATYUK'S letter to Professor N.A. Rynin (May 1, 1929):

"After I obtained my first positive results in 1917, at which time I hardly imagined that I was the first and only researcher in the field, I 'rested on my laurels'

for some time hoping for a chance to begin experiments, and to be able to avail myself of such an opportunity by implementing my inventions. At the same time I kept my work secret since I was aware of the enormousness and uncertainty of the possible consequences of man's egress into interplanetary space at the very outset of my work.

In 1918 in a back issue of the *Niva* magazine I happened on a note about Tsiolkovsky's rocket, but neither then nor for some time was I able to trace the periodical *Vestnik vozdukhoplavaniya* (Bulletin of Aeronautics) which had been cited.

This short article and others on research being carried out outside the USSR which later came my way impelled me to go on and develop a more precise and detailed theory of flight, and to go from general theoretical principles to a study of technical possibilities and their actual implementation. I worked intermittently since I was obliged to support myself by giving private lessons, chopping wood and working as a lubricator. However, by 1925 I managed to advance my research to its present stage.

In the same year, when my investigations were about complete, I succeeded at long last in finding the 1911 issue of *Vestnik vozdukhoplavaniya* (Bulletin of Aeronautics) with Tsiolkovsky's paper. I was somewhat discouraged to find out I was not the first to have discovered the basic principles. Nevertheless, I was pleased to realize that I had not merely repeated preceding research, but by using other methods I had made new and significant contributions to the theory of flight."

Academician V.P. GLUSHKO, twice Hero of Socialist Labour and a Lenin and State Prize winner: His activity, initiative and talent made him a coruscant personality. He was inquisitive by nature and never tired of searching for something new, something that would belong to him alone, and when he did find it he devoted his whole life to it.

Unaware of Tsiolkovsky's publications and quite independently, Kondratyuk applied new methods to deduce the basic equation of rocket flight. He calculated the most energetically favourable trajectories for space

flight, worked on the theory of multistage rockets, studied the feasibility of intermediate interplanetary refuelling bases, planetary satellites, and landing probes by using atmospheric braking. Kondratyuk suggested a flight to the Moon and the planets, sending satellites to orbit them. It was also his idea to utilize the gravitational fields of planets to accelerate or brake a space vehicle during its flight through the solar system.

In the *Life* magazine it was said that at the time when John Hubolt, engineer of National Aeronautics and Space Administration (NASA) watched the launching of "Apollo-9", the first manned flight of his brain child—the Moon cabin, he was thinking of another engineer (it was only recently that he had heard about Yuri Kondratyuk), who some 50 years ago estimated that the scheme providing the separation of the landing vehicle from the mother spaceship was the best possible means of landing on the Moon.

I was shown all these and other interesting material at the Yu.V. Kondratyuk People's Museum. The museum is quite unique. It is housed in buildings belonging to a grain storage establishment in the Krylovsky district in Kuban. Over the ten years since it was organized, it has received thirty two thousand visitors, some of whose entries in the guest-book are quite thrilling. One of them is very symbolic, since it belongs to the great granddaughter of N.E. Zhukovsky, a celebrated Russian scientist and the founder of modern aerodynamics: "I have been greatly impressed by this wonderful museum dedicated to a remarkable scientist and man...".

It was the N.E. Zhukovsky Aerodynamic Institute that in summer 1925 was sent a manuscript to be reviewed by scientific board. The author was a mechanic nobody had heard about. The paper was untitled and its 79 pages were carefully written in black ink. The Institute's critique was very positive. It was written by V.P. Vetchinkin, one of N.E. Zhukovsky's pupils and a future professor. He was overwhelmed by the daring and original ideas of this young scientist from the people and Vetchinkin entitled the article *On Interplanetary Travel*. He signed his review 'Vetchinkin, mechanical engineer', thus expressing his respect for the author and his solidarity with him.

Taking into consideration that Yu.V. Kondratyuk has not had university level education and that he has succeeded in everything entirely independently, one can only wonder at the talent and scope potential of this self-taught Russian mechanic.

Feeling At Home on a Planet

Yuri Kondratyuk appeared in the Kuban Cossack district in the autumn of 1925. His haversack contained no treasure other than four handsewn pencilled notebooks, filled with notes in the year he completed his studies at a gymnasium in Poltava. There were also handwritten works of the same content but developed over the years in the course of his independent studies of higher mathematics, physics, and his indefatigable obsession to do research.

His cherished dream was to conquer the Solar system, and it should be mentioned that he approached the problem from the purely practical point of view, considering it to be a project that was feasible in his own time.

In the preface to his only book *The Conquest of Interplanetary Space*, he wrote:

‘The pioneer in this field, Professor Tsiolkovsky, visualized its significance in that colonies of people will inhabit the vast territories of the Solar system until one day it cools and their rockets will carry them to more habitable worlds.

This possibility is not excluded, though it all belongs to the remote future, and what will happen then is hard to imagine. There can be no doubt that for a long time we will continue to improve conditions on our planet, which will be much more profitable than settling people outside its confines. It is, however, in the rationalization of the economy on our own planet that we should see the enormous significance of our conquest of the Solar system’.

It was his dream to have the resources to improve the land on a vast scale and even change the climate of whole continents. In his thoughts and on paper he designed a four-stage rocket, and produced mathematically irrefutable and fuel-efficient flight planes to the planets. Even in the earliest stages of his research he anticipated exactly the construction of combustion chamber heads that are still in use. As far back as 1919 he devised flotation gyro-

scopes for the control systems of rockets. His idea of utilizing the gravitational pull of the planets to accelerate or brake a rocket is crucial to projects now being developed in various countries. An example is the American 'Grand Tour' in which it is planned that the time it takes the probe to travel through our Solar system will be reduced by utilizing the gravitational fields of Jupiter, Saturn, and the other planets.

Outside the Museum there is not even the vaguest sign of outer space, though what can be seen was always close to Kondratyuk's heart. Grain, rice, maize, soya, peas and sunflower seeds are brought from throughout the Krylovsky district to this enormous modern elevator, only the name of which reminds us of that wooden store-house where Yuri Kondratyuk worked as a mechanic and where he made his discoveries. Today each of the siloes is ten times the size of the whole elevator that stood when Kondratyuk worked here.

We were conveyed rapidly to the platform of the sixty-metre operating tower by passenger lift. The grain was transported to the bucket elevators by conveyers and one can still easily recognize the "Kondratyuk buckets", which have been used for the better part of the last fifty years. Kondratyuk obtained four patents for these inventions. Three were associated with a small wooden elevator in Krylovsky, which the Germans burnt in 1942. Old workers still remember that within a year Kondratyuk had invented a meter for the automatic scales, two important devices for loading grain from the store-house onto the railway trucks, and interestingly, all the operations were controlled from a console assembled by Kondratyuk by one person alone. Nowadays, nobody is surprised to find that grain clearing, drying and loading, and the temperatures in the enormous facility are maintained automatically, without any interference by man. But at that time, even the slightest hint of such mechanization seemed to be a cosmic extravagance in the middle of the twenties. Kondratyuk also installed similar mechanisms at neighbouring elevators in Kuban and in Elkhotoovo of Northern Osetia. His name has become deeply implanted in the minds and hearts of the people throughout the whole of great Russia.

When the first Soviet satellite to orbit the Earth and

the minds of people, emerged into the vast expanse of the Universe, the inhabitants of that little Cossack village in Kuban were thinking of Kondratyuk. One woman who worked at the elevator, and in the house of whose parents Kondratyuk had once found a hearty welcome and shelter, recalled how their lodger once predicted the advent of satellites, rockets, and the flight to the Moon. This woman's story reached Valentin Ivashchenko, who had just taken up what was once Kondratyuk's job at the elevator. He became interested in it and decided to note down the reminiscences. He sent other inquiries and letters to the creators of space technology. He did not remain unheeded and now he is the director of the first Yu.V. Kondratyuk People's Museum in the country, and is an Honoured Worker of Culture of the RSFSR. The museum's archives contain a large number of exhibits he has collected and mounted. He has also managed to gather reminiscences from other villagers. *For example, V.V. SAMODOVA, the sister of the woman whose words first started the organization of the village museum, recalled.*

Kondratyuk was quite inimitable. His kindness and love of people were boundless. He only spent enough of his salary and what he received for his inventions on meals and daily necessities; the rest of his money went to workers at the elevator who asked him for material support. He wore a suit consisting of a canvas jacket and trousers, and in winter he only wore a light jacket and a cap instead of warm coat. He could have been a rich man if he had not helped others!

A marble bust stands on the Kuban soil in front of the district elevator. During the harvest, hundreds of trucks slow down before the plaque bearing the inscription: 'Yuri Vasilievich Kondratyuk, pioneer of Soviet and world cosmonautics, worked as a mechanic at the Krylovsky elevator in 1925-1926'.

From Yu.V. KONDRATYUK'S letter to K.E. Tsiolkovsky (March 30, 1930).

"Dear Konstantin Eduardovich,
Excuse me for this belated answer to your letter.
I am sending you a photograph of me when I worked
as a mechanic at the elevator in Elkhotovo. I should

be obliged if you would send me any papers you still may have. Each time I go through their list I am invariably surprised at the similarity of our thoughts in a variety of topics, and this makes your work particularly interesting to me... My new address is: Novosibirsk 'Khlebstroi'. Please send your letters registered. Yours very sincerely, Yu. Kondratyuk."

Vim and Vigour

In the centre of Novosibirsk today there is a busy bustling square at the confluence of four streets. They are Sovetskaya Street, Sibirskaya Street, Frunze Street and Prospekt Dimitrova. In the middle of the square a stele stands with the Order of Lenin which the Siberian capital was awarded. Several years ago this square was named after Kondratyuk. For the five years that Kondratyuk lived in Novosibirsk he was associated with this part of the city. In the house belonging to Safiul Sabitov, between Sovetskaya Street and Krasny Prospekt and very close to the square, Kondratyuk completed his book. Professor V.P. Vetchinkin suggested that he add a chapter to systematize the terminology, and derive a formula he had previously left out. Vetchinkin called the book *A Hand-Book for All Those Concerned with Rocket Flight*.

At the printing house of 'Sibkraisoyuz' in Sovetskaya Street the little book was published in January 1929. Its soft cover portrayed an Earth orbit with the injection trajectory into outer space and the words 'Author's Publication. 7, Derzhavin Street'.

From an interview with Professor N.V. NIKITIN, winner of Lenin and State Prizes.

'When we met, he was engrossed in the idea of transforming the energy of wind into electricity... He had enormous plans. "The air," he said, "is an eternal raw material. The energy of the air is boundless." I asked him to explain his idea. From what he said it became clear that the main difficulties would arise in construction. The generator tower would have to be both very tall and be able to rotate.'

A wind-power station had been commissioned by Ordzhonikidze, the People's Commissar for Heavy In-

dustry, and it was planned to build it on the Ai-Petri mountain. It was to supply the Crimean coast with electricity. The All-Union competition for the best project was won by Yu.V. Kondratyuk and his co-author P.K. Gorchakov. Their wind-power station was unique in the whole world. The *Pravda* newspaper wrote: 'It can generate a power of 12,000 kW. It consists of two eighty-metre wheels upon a reinforced concrete tower 150 metres high.' Ordzhonikidze ordered that the project's authors should continue their work at the Institute of Industrial Energetics in Kharkov. In July 1933, Kondratyuk invited N.V. Nikitin to help them design the construction.

They completed the detailed design and began the experiments and putting the finishing touches to their work. The group of design engineers was transferred to Moscow, but the death of G.K. Ordzhonikidze put an end to the work on the Ai-Petri. The wind-power station remained unbuilt.

In the following years the Soviet people were confronted with all the hardships inflicted by the war. Yuri Kondratyuk served during the war in the communication company of the 62nd infantry regiment. He joined the people's emergency volunteer corps of the Kiev district in Moscow and gave his life for his country near the town of Kaluga.

Years passed. The earth has recuperated. The buildings of Moscow State University on the Lenin Hills look like some hitherto unseen rocket in its upward flight. From the ashes of Warsaw the House of Culture and Science has sprung into the sky. The Ostankino television tower in Moscow rises half a kilometre toward the stars. All these are monuments to the engineering talent of Nikolai Nikitin.

In an interview given when he won the Lenin Prize, Nikitin said: "My method of designing tall buildings and structures is based on the practice I had when designing the tower for the Ai-Petri mountain. It was essentially a high-rise construction."

In conclusion, I should like to say something. Bearing in mind the number of great people who have lived in the Kuban such as Yu. Kondratyuk, A.A. Lyapidevsky (the very first Hero of the Soviet Union), the Kokkinaki

family, G.Ya. Bakhchivandzhi (the test-pilot of the first jet plane), many hero pilots of the Great Patriotic War, and the cosmonauts P.I. Belyaev and G.S. Shonin (both of whom graduated from the pilot training school in Eisk and whose feats are paradigms of Soviet patriotism and the moral qualities of young people), it would be a good idea to have a House of Aviation and Cosmonautics in Krasnodar—the capital of Kuban.

This could be a place where the boys of today could follow Korolev's maxim to live with 'zest', and construct their first models. Then perhaps one day a letter might be sent to Star City, in which some fifteen or sixteen-year-old member of this youth centre would write of a new route to as yet unknown worlds which he had calculated himself.

Part II

Bound for the Stars

Chapter II.1

CHIEF DESIGNER

Sergei Pavlovich Korolev is known to the public at large primarily as an academician, a designer of rockets and spaceships, as well as a prominent administrator. However, most people are unaware of his personal qualities, which undoubtedly influenced his creative activity. For this reason, we have decided to write about Korolev the man. This will yield into what motivated him and an explanation of his success in science and technology, in short, it will help us understand him more fully.

A Collective Portrait Formed on the Basis of the Reminiscences of Relatives, Friends, and Colleagues

M.N. BALANINA, S.P. Korolev's mother: In 1917 I took Sergei to Odessa. There we settled in a flat attached to the power station. We lived on Platon pier, and all our windows looked out on the sea, so that we saw everything that happened in the port.

At the power station there was a tall chimney stack with rings for a ladder. They made one want to climb to the top to look into the distance, but it gave Sergei quite different idea.

One day at lunch he asked: "Mother, could you spare me two new strong bed-sheets, please."

"I could, but why do you want them?"

"I shall tie them to my hands and feet and climb up the rings to the top of our chimney. Then I shall flap my hands and... start flying."

I was horrified.

"But you will kill yourself!"

"Don't birds fly, mother!"

"They do, but they have very strong wings!"

The sky drew him like a magnet. Could it have been some secret thought burgeoning under the weight of his conscious self?

A.V. FLEROV, a friend of S.P. Korolev from his youth: I have known Korolev since 1927, when he and my brother Pyotr were students at the aeromechanical faculty.

What I remember most is the day when my 'inferiority complex' (A.V. Flerov had made six attempts to enter the higher college, *Ed.*) manifested itself most poignantly. Our working day was over and we were all walking towards the Leningrad highway when we saw that there was a traffic jam. Trams leaving the stadium were hindering those leaving Byelorusskaya station as they tried to get through more quickly. I thought that it would be good to take the situation in hand. But who would have listened to me?

At this point Sergei Korolev stepped forward, took a position at the road-crossing and began to give orders for one tram-driver to stop, the other one to move on. This continued for some time and he did it with such assurance that nobody raised the slightest objection. I started to torment myself with the thought that had I not been so timid, I should have done the same.

E.M. RACHEVSKAYA, an engineer: At the beginning of the war in 1941 our small group of specialists was sent to an aviation plant which had been evacuated to Siberia. My job was to work out some of the problems connected with the work of the plant. Sergei Korolev was also working there, and I did my research under his supervision. Our desks faced each other in a large room in the chief technologist's department. People from other departments and workshops would come all the time making a never-ceasing noise that hardly allowed one to concentrate. In spite of this inconvenience Korolev was always absorbed in his work.

The news from the front was not encouraging. One day the radio outside our office played a charming and magical piece of music. I went outside. It was David Oistrakh playing Aram Khachaturyan's violin concerto. The mira-

culous sounds made me sad. I felt homesick. I wanted to be back home, in Moscow, with my family and friends. Tears ran down my cheeks, and I looked round to see Korolev standing beside me with tears in his eyes too. After looking at him, I began to cry most bitterly. He went back into the office, and when I returned, he was sitting at his desk absorbed in his work.

N.S. SHNYAKIN, an engineer: Sergei Korolev was appointed deputy chief designer of the experimental design bureau, and undertook the management of the work associated with the installation of a liquid-propellant rocket engine as a booster for PE-2 plane.

The preparations were about complete when all of a sudden the engine exploded in the air. The tail unit was seriously damaged, but the pilot, A. Vasilchenko, managed to land the plane safely. I was one of the nearest to the plane at that moment. Korolev's eye-lids, brows and face were burnt. He told me that he could not see anything at all. We immediately went to the eye clinic where first-aid was given to him instantly. The professor (unfortunately, I do not remember his name) arrived and treated Korolev. He also bandaged his eyes and told him not to take the bandage off for five days.

I whispered to the professor so that Korolev should not hear asking whether the patient would recover his sight. The professor answered that although the mucous membrane was quite seriously burnt, he thought it would recover and that Korolev would see again. For those five days I stayed close to Korolev, and at the end of the period we went to see the professor at his clinic. The professor took off the bandage, examined Korolev thoroughly and said that there was nothing to worry about now, since he was quite sure that sight would be completely restored.

Professor S.O. OKHAPKIN, Hero of Socialist Labour and Lenin Prize winner: Sergei Korolev has always been very considerate to my family. When we received a new flat, my wife asked Sergei and his wife Nina to our housewarming party. They brought a big crystal vase containing an enormous bouquet of peonies.

"Klavdiya Alexeevna," said Korolev to my wife,

"Excuse us, please, but I'm afraid we can't stay long. I somehow always seem pressed for time."

He went into every room, and noting the photographs of my father and mother and those of my wife's parents on the wall, he looked at them for some time, and then said:

"This is something you won't find in every family! How nice it is to have these pictures here!"

V.V. CHERNOV, D.Sc., a research-worker at the experimental design bureau: It was 1963. Korolev summoned me and my chief to the cosmodrome. We flew at night, and early in the morning lost no time travelling to the launching pad to report to Korolev in person as instructed. He was just leaving a little house... and right on the threshold began to express his dissatisfaction of our work. Basically, he told us that we had got conceited, stopped visiting the cosmodrome and passed the responsibility to those subordinate to us. He did not spare us to tell that he was older than we were, and yet came there regularly. We stood tired and hungry after a sleepless night and the journey. He looked at us very attentively and then after a pause said something that had absolutely no connection with what he was telling us before. "Now, if you are thinking of resigning, you can forget it!" There was another pause after which he spoke in a calm and matter-of-fact voice. He told us to be at the launch pad in the evening, and meanwhile to look into our affairs.

That evening we managed to find Korolev, who took us aside and in a quite friendly voice told us about his thoughts. He said something along the following lines: "It is enormously difficult to organize a working group of designers and scientists, but no special effort is required to disperse it." He cited the example of a well-known designer who "disregarded other people's opinion, often saying 'You're fired'. This led to many experienced colleagues leaving him. And where is he now himself? We don't even hear of him. I shall never allow this myself!" We spoke for a long time, explaining our difficulties and agreed that we certainly had to come more frequently. On our way back one thing was clear to us: it was impossible to leave Korolev even if one wished to do so.

V.V. VIDENICHEV, a fitter at an experimental factory:
In 1948 I was sent to work at an experimental section, where we assembled engines of models and reduced-scale mock-ups. We also carried out experimental work on some sections of the new rocket.

The first tests of the rocket's pneumatic systems began in March-April 1949. We had two shifts and worked 12 hours every day... I was working in the second shift once when Korolev rang up at about 11 o'clock p.m.

"How do the tests go?" he asked me.

"They have been stopped," I reported and said what was going wrong with the pipelines. Sergei Pavlovich became very angry and accused me of being irresponsible. This infuriated me and I replied angrily:

"I am only a fitter, Sergei Pavlovich. Why don't you ask the designers all these questions." Then I rang off. I did not answer the telephone when it rang again. In an hour or an hour-and-a-half the managers of the workshop and the design bureau started arriving at the workshop. When everyone had assembled, I was asked to attend the meeting, too. The first thing that Korolev said was:

"Videnichev is quite right in saying that he is not responsible for experiment. The tests should be conducted in the presence of managers and designers, who are supposed to be there and solve problems on the spot."

A.A. ZLOTNIKOV, S.P. Korolev's secretary: He liked to have some lilac on his desk. He loved flowers in general, but preferred lilac. Today near Korolev's house, which is now a museum, some wonderful lilac bushes bloom all summer. Even though tired by work, he never went home early.

Quite the contrary, he liked to remain alone when the working day was over, and then he would spread his papers over the desk, quietly singing either the song beginning, 'No bloom is better than the apple blossom', or 'Nice are the flowers in my garden in spring'.

Korolev would always have a quick lunch, and it was his custom to have tea with lemon, rye bread and a thick slice of boiled sausage at nine in the evening. He liked biting off large pieces of his sandwich. He was fond of both life and work. I don't remember him ever being ill. He could pull himself together always! Even on

January 4, he went on working till one o'clock in the morning. His exact words were: 'I am destined to die here, at this very desk!'

G.S. VETROV, D.Sc., a research-worker of the experimental design bureau: A conversation I had with Korolev in the summer of 1947 has remained indelible on my memory for the rest of my life. The rocket design bureau was only just being organized and we had problems with everything—the staff, the management and accommodation for the few of us who were its regular members. They started constructing a single building, which its first dwellers called 'the pink cottage'. It was a two-storeyed, slag-concrete, ghastly-looking edifice, in spite of the pink colour, with the corridors reminiscent of a doss-house. The 'pink cottage' became the abode for anyone working with Korolev just after the war. In those days it was a blessing in disguise for those who had no other choice but to rent private rooms.

Korolev liked to come to work when calm reigned in the design office. Occasionally he would ask one of the research workers to see him so that he could acquaint himself with the calculations or theoretical developments in a quiet atmosphere. On that summer morning Korolev was in a good mood, and he asked me several questions concerning the dynamics of controlled flight, which in those days interested him particularly. He started speaking of the difficulties connected with the organization of work on control systems and what had to be done in order to involve more industrial enterprises. Moreover, he was not speaking of the project on which the design bureau was currently working, he was discussing a new project, and said in conclusion that where the design bureau was located would be the site one day of a rocket city.

Several years later the foundations of a large beautiful house were laid. It was built for the employees of the design bureau, and even today it is known as 'Korolev's' house. Thirty years later a modern city rose where once there was a settlement; the city with a vast avenue named after Korolev, on either side of which eighteen-storeyed houses rise high into the air.

A.N. VOLTSIFIN, Cand. Sc., a research-worker at the experimental design bureau: A fitter made a mistake when assembling the hydropneumatic system of a rocket (one of the valves was not properly installed and the entry and exit were mixed up). The first launching of a new rocket was therefore not accomplished. Korolev sent me to some very high-ranking establishment with the drawings of this valve so that I could report on what had happened. I don't know how grey my head became after I told them about the unfortunate event (my hair was already grey enough at that time), but from then on there was never a case when the dimensional characteristics at the entry and exit were disregarded in the construction of fittings.

For a long time—and now I can even say, for the rest of my life—I have remembered what Korolev said about the 'rules' which any manager should adhere to. He would often reiterate them.

One of them was, 'If you do something quickly, but badly, everybody will soon forget you did it quickly but they will all remember for a long time that your work was bad. By contrast, if you have been slow, but what you did was good, they will soon forget you were slow, but will remember how good the result was.'

Guided by these instructions we all did our work fairly well and so quickly that all the tasks undertaken by Korolev won us universal acclaim.

The second dictum Korolev employed, if jokingly, was, 'If you want to let your chief down, do exactly what he says and as quickly as you can!'

... Once I asked Korolev to help one of our people who had had a car accident get treatment at a Moscow hospital. He gave me a good scolding and expressed his strong opinion that the accident was the man's own fault. However, two or three days later the man was being cared for at a special clinic.

E.M. KRASNOVA, a teacher: I had been working at schools in the town for many years. In summer I was often asked to be a tutor at a pioneer camp run by the enterprise headed by Korolev.

In 1957 the attic at our school caught fire. The first to arrive was Sergei Pavlovich Korolev. He was greatly

perturbed. The fire was extinguished, but the fact that such a busy person had left business to help the children speaks volumes concerning his attitude to them.

V.A. KOSHELEV, an engineer at the experimental design bureau: In 1960 the Tungus meteorite phenomenon had once again become a focus of attention. I went to Korolev's assistant with the suggestion that an expedition to the region where the meteorite had fallen should be organized. The next day I was wanted on the telephone.

"Korolev speaking. Please come to my office, Koshelev."

I hurried along, not feeling at all surprised. I was a young engineer at that time, and it seemed to me quite natural that a chief designer should treat a rank and file engineer without formality. Now, after so many years, I don't think so any more.

On entering his office, I greeted him and said who I was. The paper I had written was lying on his desk.

"And what do you require?"

I recited a list of all that was necessary to organize such an expedition: from the documents needed by the participants to their dispatch to their destination. The number of items including equipment, ranging from radiometer to helicopter, was impressive.

"Well, you'll have all that."

I left his office, not feeling particularly glad. Our conversation had been as short as it possibly could be, and I was experienced enough not to trust implicitly what authorities promised.

I could hardly believe my ears when on the following day I was asked to see the commercial director with the list of the equipment I required. The preparations began immediately....

Preceding our departure everything was done so opportunely that there seemed to be some magic wand behind it all.

N.D. BONDARENKO, chief of the expedition at the cosmodrome: In Baikonur Korolev lived in a little prefabricated house. Once on leaving it and closing the door behind him, he pointed to the top of the porch and said:

"The pigeons have found a home in the portico ever

since I moved in. I have got so used to them that I can't even imagine how it would be without them. I should like you to tell all the members of your expedition that the turtle-doves are under my aegis and I pity anyone who takes it into his head to harm them." All this was said with a smile.

Then it became clear to me why Korolev did not want to have a terrace attached to his house. Were one built, the pigeons would lose their home.

G.Yu. MAKSIMOV, Cand. Sc., a research-worker at the experimental design bureau: In 1961 a probe was in the assembly-and-test building altitude chamber at the cosmodrome. Leakage tests of the completely assembled object were in progress. In the middle of the night I was summoned to the assembly-and-test building from the hotel by the designer who was responsible for preparing the probe. The problem was that the leakage was three or four times greater than permissible. Could the probe be allowed to take off? I could still not have fully woken up for which reason I was a bit too calm. I multiplied the measured leakage by the flight time and divided it by the free volume of the section, with the result that I obtained a drop in pressure which I then compared to the range of pressure admissible in the section. It was within the specifications of those who developed the instruments. The result was quite satisfactory. I gave my 'permission' to the engineer in charge, and conscious of having done my duty I left the assembly-and-test building to catch up with my sleep. Just as I was leaving my exit was impeded by Korolev. By the manner in which he was moving towards me along the corridor I understood only too well that I was in for trouble, though I did not feel at all guilty. His first words were: "Who allowed you to permit the flight? You don't seem to know who your chief designer is!"

I explained my calculations. "Was the permissible norm fulfilled before?" he asked. "It was..." "Well, why do you think the norm is not being fulfilled now?" At that moment I became aware of the imbecile academicism of my own calculations. As he was watching me closely Korolev saw that further edification would be pointless. He immediately ordered the engineer in charge to extract

the object from the low-pressure chamber and examine it thoroughly. As a result, it was found that several bolts holding the leakage joints together were not fastened tightly enough. The joint could have opened wider and the drop in pressure in the section would then have become much larger than what I had estimated. After correctly reassembling the unit, the norm was as per the drawings. In the years that followed Korolev never reminded me of the incident.

K.S. SHUSTIN, Cand. Sc., a research-worker at the experimental design bureau: In 1964 a very funny thing happened, indeed it soon became a legend. We were extremely surprised when quite unexpectedly a telephone-operator entered our workroom, disconnected all the telephones, put them into a big bag and carried them away. All the other design subsections shared the same fate.

At that time, the "Voskhod-2" spaceship was being designed to allow a cosmonaut's extravehicular activity. Korolev paid special attention to this kind of work and often spent the first part of the day helping with the design work.

Frequent telephone calls became a nuisance for those who were supposed to discuss technical matters with Korolev. Hence, he prohibited telephone calls in the morning. However, people continued to use the telephone on the pretext that their discussions were urgent. Korolev could stand it no longer and ordered the telephones be taken away from where designers worked. On the following day, scores of questions remained unanswered because there were no telephones. The number of urgent problems increased. We went to our direct superiors, and they approached Korolev. He understood the situation perfectly, and yet remained adamant. Several days later the lesson in the scientific organization of labour came to an end with the designers getting their telephones back. They were also ordered not to use the telephones until 11.30 a.m. The morning was for creative activity alone.

K.P. FEOKTISTOV, pilot-cosmonaut of the USSR: Sergei Pavlovich was shown a chart with the earliest

optimum dates of flights to the Moon, Mars, Venus and other planets. Against each planet and within a particular interval of time the optimum dates were repeated: every 19 months for Venus, every 25 months for Mars and so on. On the chart the dates produced the impression of a front distributed in time. I still remember well how Korolev moved his hand very softly and said that it would not be bad for us to take the upper initiative and to be the first everywhere. It sounded a bit funny and even naive, but isn't the desire to steal the discoverers' thunder ambition pure and simple? Ambition was part of Korolev's nature, yet it is this attribute that enables one to move onwards.

A.V. PUSTOVOITENKO, Chairman of the City's Executive Committee: The city's water supply was half as much as we required, and the only way to overcome the shortage was to develop the artesian well supply. Fortunately, the builders were ready to start work on a large scale and the various enterprises promised finance to share the expense. However, a conversation I had with Korolev's deputy R.A. Turkov instantly cooled my ardour. I gave him a full account of the city's water-supply situation and pointed out that when the water-pump station providing 50 m³ of water per day began to operate, the bureau would have a substantial reserve, but meanwhile the situation would be extremely difficult even for Korolev's experimental design office. I asked Turkov to order an immediate halt to the design work on the pipelines, since decision the other enterprises had taken concerning their sponsorship of the project would alter the plans.

I tried to convince him that if the construction of the water-pump station and the pipelines were prolonged, the City Council would be compelled to stop building living quarters, including homes for Korolev's experimental design bureau. This was out of the question since there were far too many families in the city requiring better living conditions and waiting for proper accommodations. My words had no effect on Turkov.

"The water from the canal is allotted to our enterprise and not to the city, and there can be no question of discussing the matter any further. I advise you not to claim

something that doesn't belong to you," were his exact words.

It was particularly bitter for me to hear this from someone I respected for his sense of responsibility, loyalty to what he was doing, and as a good person who had had a difficult life. I could do nothing else but contact Korolev personally. I repeated everything I had said to Turkov, but his reaction was very different. Korolev paced his office, and said as if he were thinking aloud:

"I don't think we should be happy for our own water pipelines pass by houses where people don't have enough water if we begrudge them our extra water. Besides, Alexandra Alexeevna is quite right, the City Council could never allow us to do such a thing."

I can say this now quite openly and without blushing, but what Korolev said made me catch my breath. I was on the verge of tears and felt like a child, who had been mistreated by everyone and whom nobody wanted to understand. Then along came a kind and gentle person who took pity. It was my nerves; for on the whole this was the first time when persistence was required to solve the city's problems.

Korolev immediately telephoned the assistant responsible for construction and asked if the pump station contractor could double his work-load for the year. Then he rang off and said:

"It turns out that the contractor is not only willing to do as you ask, but actually insists on doing so because it is not remunerative to prolong work at this site for four or five years." Korolev smiled and said to his deputy: "I'm afraid nothing can be done. They all take the city's side."

A.S. ELISEEV, pilot-cosmonaut of the USSR: I happened to see Korolev's work at the control centre when the "Voskhod-2" spaceship returned from orbit. Something very unpleasant and unexpected had occurred: the automatic control system failed to maintain the orientation of the spaceship before landing. Nobody understood why and several people started speculating. It was clear that everybody was nervous, and at this moment Korolev took the situation in hand. He demanded silence and asked us all to take our seats. He then calmly listened

to what the person in charge of the control system operations had to say. Korolev inquired what could have caused the system to malfunction and asked the man to suggest further action. It was suggested that craft be reoriented manually. In spite of the fact that this kind of descent knew no precedence, Korolev consented. He himself informed the crew of the decision that was taken in a voice so calm and confident that the normal working atmosphere was restored both on board the spaceship and down below. He also asked Yuri Gagarin to pass instructions onto the crew. Because of the delay, the descent vehicle landed in an area that had not been planned. The weather was bad and they had to look for the vehicle for some time. Korolev remained unceasingly in contact with the search party, and saw to it that they did their work effectively and safely for the aircraft. The clouds were very low and it was necessary to avoid collision between the helicopters. When at long last the cosmonauts were found, we realized what Korolev had lived through during those hours. The first thing he said to someone was: "Now let someone bring the State Commission half a kilogram of some tranquilizer."

Instances of Fate

G. GRECHKO, twice Hero of the Soviet Union, pilot-cosmonaut of the USSR, D. Sc. (Phys.-Math.): It so happened that I began my career at the design bureau headed by Korolev. We did not see the chief designer very much at all even on business. However, each contact with Sergei Pavlovich was always an event in itself. I think what attracted us was his personality and the power of his intellect. Now, after so many years, we (Korolev's people) never tire of saying that there are many things in life for which we are indebted to our teacher. The notes that I have prepared for *Sovetskaya Rossiya* newspaper are the episodes that have remained indelible on my memory, which, I think, can give an idea of the chief designer as a person.

I can never forget the first time I met Korolev. I had the opportunity just after I graduated from Leningrad Mechanical Institute and came to work at the design bureau.

Then someone said to me: "The chief has asked for you to go for a talk." I must admit that this was something I had not expected—the head of such an authoritative organization wishing to speak with a subordinate who had only recently graduated. What about?

Our conversation lasted for almost an hour. We discussed study at the Institute, life in general, books, the theatre and various other things. Korolev proved to be considerate interlocutor, and I felt that his attention to me was not a mere formality, but that he was actually interested to know more about a new engineer who came to work under him.

Although he was busy, he always found time to such talk with practically every newcomer. As soon as he got to know the young person he would encourage him or her not to keep quiet if he or she had some idea. In fact, he encouraged everyone to speak out in defence of one's opinion, since it is only through discussion that there can be any rational outcome, whereas indifference never gives birth to anything.

This is why his collective was invariably a body of people in concord.

... Korolev was never lenient. He was harsh and hot-tempered. All of us who worked at his design office knew that he was merciless when he saw someone being careless or inattentive.

I remember once walking with a friend, when he was told that Korolev wanted to see him immediately. I have never seen a man turn so pale. "Oh, you can't imagine what is going to happen!" he kept repeating.

But we also knew that Korolev had a forgiving nature. One day during a meeting with an assistant, who had not done his work in time, Korolev lost his temper:

"Go and return your pass. You are dismissed!"

The man walked out of his office.

Two hours later Korolev rang him:

"Well, how goes the project?" asked he.

"It doesn't," his assistant replied. "You dismissed me."

"Don't talk nonsense. Don't waste time, you have too little of it, anyway."

Then Korolev began to speak of the new task.

Those whom he chided most were the people he really loved.

... One of my first trips to the testing grounds began with an emergency. I discovered a mistake in my calculations, and it was necessary to make a decision immediately, since only two days remained before the launch.

I made up my mind to go and see the chief.

He listened to me very calmly and advised me to get in touch with Moscow and tell them about my doubts.

The head of my department was furious. His argument boiled down to the view that there could not have been any error and that it would be much better for a young specialist like myself to mind my own business. I found out later that he repeated his point of view to Korolev in practically the same way. Korolev did not comment, he only asked that the calculations in question be verified.

I provided the data and heard: "Wait! We shall ring you up in an hour."

One hour passed, one and a half hours..., two hours.

The telephone rang.

"You are right. There is a mistake."

So as to prevent the launch schedule from being upset, I decided to recalculate the problem by hand.

Korolev found me late that night and asked over the telephone why I was not in bed.

I answered that I was pressed for time to complete my work.

"Well, O.K.," he said, "go on".

It was an experience for me—his confidence in me.

... Even those who knew Korolev well were surprised at the tasks he was ready to tackle. For want of a better word they were occasionally insurmountable. On the day after the triumphant launch of the first satellite (October 4, 1957) we found out that by the seventh of November another craft had to be launched, and a very unusual one at that! The next space vehicle was to carry a dog. It was therefore necessary to provide a pressurized cabin, a life support system for the animal, and a host of other things. We understood only too well that the project's development phase alone would take several months. We had thirty days!

Korolev went to the shop floor to talk to the workers.

His speech was very short:

"We have an important government assignment, and

there can be no question of first doing the design, then checking, and then testing. Instead of drawings you will have rough drafts: your working class conscience must function as the checking department."

The workers kept faith.

A month later Laika the dog went into space.

... Once Korolev asked us to come to his office. We all got ready for a 'brain storm' over some problem. Instead, Korolev had organized a competition for the best name to give the ship in which the first cosmonaut was to orbit the Earth.

A torrent of suggestions was forthcoming:

'an interstellar vehicle,'

'a rocket vehicle',

'a cosmic vehicle',

Nothing was right.

"So, then," said Korolev, availing himself of the privilege of seniority, "we shall call the module 'a spaceship'."

This was how this very precise term defining the new type of transport entered into all the languages of the world.

... The night duty officer was to remain in the chief designer's office at night and answer telephone calls, and contact Korolev himself at home when something extraordinary happened.

Korolev allowed the man on duty to stay in his own little private study rather than in the big room where he usually held his meetings.

On many occasions I took my place at Sergei Pavlovich's desk after eleven o'clock at night. Right in front of me stood his books, articles he had been sent, various accounts of the work that was done, and manuscripts. They touched on a very diverse range of subjects from science and technology to the Arts. It was in this little room that I first realized that Korolev was possessed of a quite unusual erudition, had a vast range of interests, and read incessantly. Many projects were only implemented when their author was no more with us, and they had originated in this very room.

... When the multi-man spacecraft was created at the design office, engineers and designers from the department began to ask Korolev for permission to be recruited as cosmonauts. The number of those wishing to joint

the team was more than could be imagined. However, only thirteen of us remained on the list after the medical commission, and we were asked to go and see Korolev. He spoke very briefly about future missions and then suddenly asked:

"Why do you want to go into space?"

Our answers were very much the same and seemed quite appropriate:

"We want to apply our knowledge not only to create the spaceship here on Earth, but also to carry through the programme of the flight itself."

The more Korolev listened to us, the graver he became. Then he lost his temper and flew into a rage, promising to disperse our team altogether. We could not understand what was wrong.

Today, many years have passed, I understand why he was displeased with our answer. Sergei Pavlovich had a boyish dream that there would be a time when the medical demands would be relaxed and he would be able to go into space himself. That was why when the candidates were gathered in his office he was expecting to hear from those he envied something more in line with his own thoughts. What made him angry, however, was that he did not hear us say anything that went beyond the mundane.

... When the discussions about the Tungus meteorite reached saturation point, some of us, the younger engineers at the design bureau, went to see Korolev. We told him that we should like to join enthusiasts from Kiev and Tomsk and go to the site during our holidays in order to gather data that might substantiate the hypothesis that it had been an alien spacecraft.

Korolev not only supported the suggestion, he also offered us the use of a helicopter—the property of the design office that was stationed fairly close to the site and which could be utilized for our explorations. He ordered that we be provided with radio transmitter-receivers and said in conclusion:

"Now, as for money, I'm afraid I can't do anything for you."

"It's quite alright," we said, "we shall have our holiday pay."

"I'm not sure it'll be enough." He thought for a while: "Look, why don't you apply for some financial help?"

A week later I was reporting to Korolev over the telephone about our efforts in the taiga and swamp.

"Have you discovered any remains of a spacecraft?"

"No, not yet. But we are trying our best. However, the holiday is already coming to an end."

"I shall prolong it," he said at once.

I had to tell him that we had promised our departmental heads to be back in time.

Korolev acquiesced, and said that business was business. Then he added:

"Still it's a pity that you did not find anything. Don't lose hope, anyway."

... I think that it was on Thursday from three to five that people could consult Korolev on personal matters. However, everyone at the design office was aware of how to solve such problems with the chief designer. It was an open secret that all one had to do was to meet Korolev at the entrance to the design office in the morning and go up the stairs with him to his room. There was quite enough time to discuss any request and receive a straight answer.

... Korolev is often portrayed as having but one passion, and whose life revolved entirely around rockets, drawings, devices. This is far from being true. He was an ordinary person, who could experience both joy and sorrow, and who was sometimes absent-minded.

This is a story I heard about him.

In his youth Korolev liked to drive a motorcycle. Once, he was in a hurry to get to some place, when something went wrong. He managed to get to the city only with great difficulty. Cold and hungry, he dropped in at a bakery along the road, bought himself a bun, and ate it right away on the pavement.

Many years later as chief designer he was on his way from some conference and saw that he was passing by the old bakery. He stopped the car and went into the shop. The people were surprised to see a man sitting on the pavement near a very fashionable car with a bun in his hands.

I cannot vouch that the episode is entirely true, but

it would have been in Korolev's character to do a thing like that.

... Nowadays the moment a huge cigar-like rocket leaves the open doors of the launch gantry can be seen by everyone on television. In the sunlight the copper-red nozzles of the engines seem more like some sort of unearthly blaze, and the rocket appears to be from a science-fiction film.

On the eve of a launch we occasionally try to look at the spectacle, but the rules at the cosmodrome are rigid and during a launch no one is allowed near the pad.

On one occasion Korolev's car stopped at the barrier. He looked at us, thought for a moment, and then said in a voice which sounded like an order:

"Get into my car."

Korolev stopped his car on an elevation.

"This is the best spot."

Then it dawned upon me that Korolev used to come to this place especially to enjoy the sight. What a romantic he must have been to rush there each time at sunrise to drink in the enchanting scenery—the product of his handiwork...

Chapter II.2

THE KELDYSH ORBITS

Mstislav Keldysh

Academician A. ALEXANDROV, three times Hero of Socialist Labour: Mstislav Vsevolodovich Keldysh is associated with some of the greatest achievements in his country's and world science and technology, as well as with the establishment of new scientific trends. Continuing the traditions of outstanding Soviet scientists, he did fundamental research into aerohydrodynamics, his work on fluttering being very significant for progress in aviation. He encouraged the progress of applied and computing mathematics and the development of computer engineering in the Soviet Union.

As a scientist, communist and patriot Keldysh was in the midst of the cardinal problems of his day. When at the end of the forties the USSR had to solve the atomic

problem, it was under his guidance and with his direct participation that the required mathematical methods were elaborated. He was one of the administrators of the scientific research on his country's rocket-and-nuclear shield.

Keldysh also made a tangible contribution to the establishment of the Soviet Union as the first space power. The diverse problems encountered in space research were solved under his scientific guidance.

As head of the USSR Academy of Sciences for 15 years, he contributed substantially to the progress of Soviet science and the improvement of its organization. He ardently supported the idea of close links between science and the everyday needs of life.

Academician M.V. Keldysh's merits were recognized and he was made Hero of Socialist Labour three times and was awarded the Lenin and State Prizes.

Academician P. FEDOSEEV, Vice-President of the USSR Academy of Sciences, Hero of Socialist Labour: When M.V.Keldysh was President of the USSR Academy of Sciences, he frequently stressed that the successful operation of the Academy relied on a correct distribution of scientific potential between fundamental research into the laws governing nature and society, on the one hand, and the development of contemporary problems that are brought about by technical progress, and the economic and social development of the country, on the other.

In those days, he was officially proclaimed the theoretician of cosmonautics, and yet, although engrossed in space research, he considered work on other scientific topics to be important too. He spared no effort in promoting fundamental research and theoretical problems of the economy of socialism. He never tired of emphasizing that history, philosophy, and the other social sciences were vital to the solution of the tasks confronting the building of communism.

Nowadays the development of scientific investigation itself, as well as technical progress and the growth of industry, generate global scientific problems which can only be solved by integrating scientific and material resources. M.V. Keldysh did very much to organize and promote international scientific cooperation, as he was

perfectly aware that the international ties between scientists encourage a better understanding between nations, and the strengthening of peace.

His Gift of Foresight

Progress in science is impossible without overcoming the difficulties. Science calls for heroism, and this is what youth is in quest of, and where it visualizes its happiness... That is why the influx of youth into science is only natural...

M.V. Keldysh

Lyubov Vsevolodovna KELDYSH (M.V. Keldysh's sister): In the twenties we lived in Antipyevsky lane in Moscow, in the semi-basement of an old house. Our family was very large and consisted of father, mother, grandmother and seven children.

We were all very friendly. In the evenings, sitting at the round table over our supper, we used to discuss our current affairs. At one such discussion, involving the whole family, my brother Mstislav's future was determined when he left school at sixteen. Father wanted him to become a civil engineer. Mstislav did not object, but an unexpected problem cropped up, that is, one could not be matriculated until one was seventeen.

Our eldest sister, Lyudmila, who was already a postgraduate at the mathematics department of Moscow State University, suggested that Mstislav should join the university. She promised to ask the eminent professor of mathematics N.N. Luzin for his permission.

Thus, Mstislav became a student at Moscow State University. Father took it very badly: his son was occupied with some kind of mathematics instead of doing something really serious.

In his third year at the University, Mstislav started teaching at the State Institute of Electrical Machines.

Vera Vsevolodovna KELDYSH (another of M.V. Keldysh's sisters): There can be no doubt that the money Mstislav received for teaching was a useful addition to our family's budget. But that was not all. The work he did helped him understand better various aspects of

mathematics—the subject that would occupy his whole life.

The only recreation he allowed himself in those days was music. He tried his best not to miss a single first night at the Conservatoire or the Bolshoi Theatre. I must say that tickets were not readily available even then, and he often had to queue the whole night, irrespective of weather.

Once I said surprised: “But don’t you have any rest at all?” “I do relax when I listen to music,” was his answer.

At twenty he graduated from the University. At about that time he became interested in a new field. He was drawn into it by Mikhail Alexeevich Lavrentiev (the future academician and the first chairman of the Siberian section of the USSR Academy of Sciences).

Aviation during thirties was dealing with aircraft that were flying at new velocities and a mathematical theory that could meet its demands was urgently required. My brother threw himself into some of the practical problems.

His scientific adviser, Professor N.N. Luzin, was adamant that Mstislav should concern himself entirely with “pure” mathematics, and he was profoundly frustrated. When he met father, he commented:

“Your son will ruin himself. We must do something to help him.”

He saw that father did not understand him, and expressed himself more fully.

“Your son got into the hands of Lavrentiev, whose detrimental influence is only too obvious, since he wants your son to study applied mathematics.”

Father’s reaction, however, was quite different. In fact, he supported his son’s desire.

My brother’s extraordinary talent began to gain recognition.

Academician M.A. LAVRENTIEV, Hero of Socialist Labour: In 1934 the Mathematics Institute headed by Academician I.M. Vinogradov was organized. I and M. Keldysh worked together in one of the institute’s departments.

Academician Vinogradov was very fond of scientific discussions. One of them concerned us in particular.

A report was made at the seminar by a prominent scientist from Leningrad. He presented a number of calculations and said that since he had been racking his brains for over ten years on this problem, he was now convinced that it could not be solved. M. Keldysh and I quietly went into another room, and by employing various approaches we obtained a complete solution. We immediately returned to Vinogradov's seminar, and showed the downcast Leningrader how the 'problem' was solved using our method.

State Prize winners Professor Ya. PARKHOMOVSKY and Assistant Professor K. POPOV: In the thirties, when new experimental airplanes were being tested, structures began to collapse spontaneously at some ultimate velocity. The pilots who were fortunate to survive could say no more than the accident was preceded by unexpected intense shaking or flutter of the vehicle.

Sometimes, it took the ever-growing vibration no more than one or two seconds to destroy the plane. Such disasters were on the increase, and flutter was becoming the scourge of aviation.

Research conducted by M.V. Keldysh and his scientific school enabled the Central Aero-Hydrodynamic Institute to predict for each plane the velocity at which it could be threatened by flutter and develop techniques for suppressing it. The new methods were severely tested during the Second World War. Thus, we were able to avoid the accidents and disasters that accompanied the development of aviation outside the USSR...

In 1938, when Keldysh was 27, he was awarded the degree of Doctor of Sciences.

Stanislava Valerianovna KELDYSH (M. V. Keldysh's wife) recounted the following: It was October 1941. The Central Aero-Hydrodynamic Institute was being evacuated to the rear. We reached the railway station with great difficulty. We had two little children; Svetlana was three and little Petya was only several months. The train started and we had to run to get on it as it was already moving.

Kazan was packed with evacuees. The problem everybody felt most acutely was that of food. This was par-

ticularly so in families with little children. Mstislav was working from morning till night.

Suddenly he was ordered to go to Moscow (I think it was in December).

He returned home for only a few minutes and then went straight to the airport.

For several days there was no news from Mstislav at all. I tried to contact people at his office, but they also seemed surprised that Keldysh had stayed away longer than he was supposed to.

Then, the door suddenly opened and I saw him standing there somewhat depressed. I embraced him, but decided not to bother him with questions.

Later I heard what actually happened. On the way back from Moscow the plane landed in Gorky, and for some reason it was decided to replace the plane. The new plane had not been properly factory tested but was rolled out of the hangar.

Mstislav was about to get on board, when the pilot said:

"Don't hurry, please, let me fly round the field first."

The plane ran along the runway and then took off into the sky. It circled once and just as the pilot was about to enter a second one, it seemed to encounter an obstacle and plummeted downward. Several seconds later there was an explosion... Mstislav did not like to speak of what had happened then...

Then Central Aero-Hydrodynamic Institute soon returned to Moscow. The heads of the families were to leave first, with their wives and children remaining temporarily in Kazan.

Before his departure Mstislav wanted his little children to have at least some food, and so we went to the market to sell our only valuable possession—a gramophone with a set of favourite records he had been collecting for years.

We stood at booth with the cries 'Potatoes, not rotten potatoes,' 'Rolls...' reaching our ears from all sides. Shaliapin's bass and arias from the operas streamed out of our gramophone, for which we received a small bag of rolls and some cereal.

He Was Creating a Shield

An awareness of the boundless possibilities of science and technology in harnessing the forces of nature, which is stronger than ever before as space research progresses, has an undoubted beneficial effect upon our sense of responsibility for the fate of our planet—a responsibility that has recently been increasing.

M.V. Keldysh

Academician I.M. VINOGRADOV, twice Hero of Socialist Labour, and Director of the Institute of Mathematics of the USSR Academy of Sciences: Soon after the war, I was asked by Yu.B. Khariton and other physicists to recommend a mathematician who would be able to do the calculations for a certain atomic problem. I told them that Keldysh was better than anyone else at using mathematics for applied purposes.

Academician A.N. TIKHONOV, Hero of Socialist Labour, Director of M.V. Keldysh Institute of Applied Mathematics: The gigantic nuclear problem, which called for enormous efforts, was solved within a very short period of time. The Soviet Union took very little time to create a nuclear missile shield and outstrip the USA in the peaceful use of nuclear energy. This success would not have been feasible without a wide-scale use of mathematical design, which provided every opportunity for the choice of optimum variants for constructions and thus enable the engineer to enhance substantially the pace at which technical progress gained new horizons.

M.V. Keldysh participated in this great task both directing a large body of scientists and generating ideas.

K.I. BABENKO, Corresponding Member of the USSR Academy of Sciences: Even though M.V. Keldysh was heading a prominent Science and Research Institute and was already an academician (he was elected in 1946 when he was 35), he nevertheless remained quite accessible.

He always arrived at his office at nine o'clock in the morning, and would speedily deal with administrative matters. Anyone wishing to see him could do so before lunch-time.

After a snack which, as a rule, consisted of a cup of tea and a sandwich at the Institute's cafeteria, M.V. Keldysh would lock himself in his study, where he dealt with purely scientific problems. He would ask his interlocutor to take a seat at the other side of his desk and would watch him very closely during their talk. He remained imperturbable, smoking incessantly. There were instances, however, when he would hastily run to the blackboard to express his thoughts with the help of formulae.

He went home at about ten or eleven in the evening.

The most striking thing about him was his scientific intuition. He had an extraordinary way of handling things, even in those domains of mathematics with which he was not particularly interested. He was a quiet man but he would neither disregard nor tolerate any prevarication in matters of scientific research.

Academician V.S. AVDUEVSKY, winner of Lenin and State Prizes of the USSR: Just after the war M. V. Keldysh was appointed head of the 'rocket' Science and Research Institute. In this capacity he reorganized its activity and directed the efforts of its scientists at the solution of the main problem, which was to create the basis for rocket production and cosmonautics. Those working at the Institute, some of whom were famous rocket technology experts and prominent scientists, soon became aware of their new director's quite unusual talent as an organizer and manager.

M.V. Keldysh's reputation and authority were very high. When discussing any problem or making a decision, he invariably adhered to what was best for the Institute, discarding any other, especially ad hoc, considerations. He managed to implement the idea of producing a large quantity of inexpensive rocket carriers for a wide range of scientific experiments in outer space using the small satellites in the "Kosmos" series. His foresight and determination made it possible to develop and modify the "Proton" rocket carrier and thus increase the scope within which the Moon and other planets could be studied.

Ya. PARKHOMOVSKY and L. POPOV: Mstislav Vsevolodovich adhered to the opinion that no one managing others could know any particular field better than the person directly working in it. Once he said: "Even Stanislavsky (the Russian theatrical producer) cannot play all the parts himself." The main function of the head of an organization is to delegate to people. And Keldysh really knew his people and trusted them. He preferred to convince them rather than merely give orders. He would often repeat the phrase: "This is a scientific establishment and not a military regiment."

G.M. GRECHKO, twice Hero of the Soviet Union, pilot-cosmonaut of the USSR: In the fifties I worked as a ballistician under Sergei Pavlovich Korolev and was in charge of a group of people doing calculations. The computation of the rocket trajectory was performed manually, though we had electrical arithmometers and six-digit trigonometrical tables.

Rocket engineering was then entering a new stage of development. The launch of the first Earth satellite was soon to occur, and we had to calculate its trajectory. It was suddenly realized that our six-digit tables were insufficient and that they had to be replaced by the eight-digit ones. We were busy with calculations practically day and night. The work was becoming ever more difficult. We were terribly pressed for time, to say nothing of the responsibility for having to do it all without a single mistake!

Then help came from Keldysh. The department of applied mathematics, which he headed, offered us the use of the first computer for our ballistic calculations, and although it could do not more than ten thousand operations per second, it was a step forward.

Often practical cosmonautics was confronted with difficulties, and solutions were suggested by Keldysh which enabled it to move onwards.

We lose a great deal by inadequately analyzing the state of the science at each given moment and by not taking into account the possibilities that new discoveries have for theory and practice.

M.V. Keldysh

Academician B.E. PATON, twice Hero of Socialist Labour, President of the Ukrainian Academy of Sciences: Mstislav Vsevolodovich regularly visited the republican academies and was well aware of the situation in science throughout the whole country and could thus efficiently direct each of its centres towards the fulfilment of new assignments.

We could not but wonder at his ability to help everybody in his or her work. What lay behind it all? Certainly his erudition! But where did it come from? It could not have simply been a natural gift or perfect memory. Undoubtedly his inquisitiveness and energy were important factors.

I think that what I have in mind will become much clearer if I say some words about his daily routine when he was away from home. He would get up before six in the morning and walk along the streets of an unfamiliar town when all the establishments were still closed and when the stillness was undisturbed by traffic.

Once in Donetsk, when it seemed to me that he was exhausted, Keldysh insisted on going to see the Oktyabrskaya mine. He dressed appropriately and went down the shaft. He breathed in quite a lot of coal dust, but did see the new combine at work.

It is difficult to say whether he ever got tired. At one time Mstislav Vsevolodovich was visiting scientific centres in the Ukraine when Soviet space probes were approaching Venus. He did not want to miss a single transmission session. For two nights running he worked at the Centre for Long-Range Space Communication in the Crimea, but did not interrupt or slacken his work with us. In the evenings he would fly to the Centre, only to return in the morning.

Academician L.A. ARTSIMOVICH: Keldysh was not one of those officials who saw their main duty as being

a passive breakwater with which matters of current importance collided before they receded carrying a desired verdict upon their crest. Keldysh was an inaugurator of turbulence and the initiator of transformations and beginnings designed to enhance the activity of that living organism known as Soviet science.

Academician V.A. KOTELNIKOV, twice Hero of Socialist Labour, Vice-President of the USSR Academy of Sciences: His gifts enabled Mstislav Vsevolodovich to traverse without difficulty in various branches of science, and to notice buds of anything new.

Thus, in spite of the scepticism of certain prominent physicists, he unwaveringly supported Soviet research on quantum electronics and holography. Another cogent example was the development of new biological studies, primarily molecular biology, that emerged as a result of the penetration of methods of physics and chemistry into the research of living matter. Soviet successes in molecular biology and genetics are greatly indebted to M.V. Keldysh as President of the Academy.

Academician N.P. FEDORENKO, Member of the Presidium of the USSR Academy of Sciences: M.V. Keldysh had a gift of foreseeing the long-term development of science. I can still remember how at the beginning of the seventies the Academy was working on an integrated programme of scientific-and-technical progress and its social-and-economic results for the period 1976-1990. This kind of work was unprecedented. It involved immense difficulties and was fraught with mistakes... In spite of his many commitments Mstislav Vsevolodovich regularly involved himself in this work, contacted those participating in it, and persistently tried to have the calculations verified and reverified, so that the most important tasks facing science and technology could be brought out and formulated. Heated discussions occasionally continued well into the night. Without exaggeration it can be said that these discussions, though strenuous and exhausting, were invariably productive, and that period of my life has remained indelible on my memory.

I.M. MAKAROV, Corresponding Member of the USSR Academy of Sciences: Mstislav Vsevolodovich had the same

uncompromising attitude to others as he had to himself. In his opinion, a prominent scientist was not the one who had written hundreds of treatises and made scores of inventions, but the one who had penetrated into an undiscovered truth and thus solved a scientific problem over which scientists all over the world had been racking their brains. (Note that Keldysh himself had solved several problems of this kind.) The most significant and promising trends of research at the Academy of Sciences were now headed by those who could be called prominent in science.

Keldysh was a gentleman who was forgiving. Only once have I heard him raise his voice, but even on that single occasion he smiled as soon as "the guilty parties" left his office, and said:

"Well, I did scare them, didn't I?"

Once somebody said to Keldysh:

"You are a tactful person, Mstislav Vsevolodovich, whereas Korolev often loses his temper..."

Keldysh disagreed:

"I know that he can give vent to his feelings, he can even slam the door behind him. But if he sees that he was wrong, he will come back and apologize."

Keldysh himself used to seize Korolev's meaning at once and they had always been unanimous at conferences.

Did he have any interests outside science? He did have some, though it should be said that Keldysh had practically no time for any kind of recreation.

I remember that during a trip to Italy, we had visited several scientific establishments, and then were taken to several picture galleries in Milan. It was the first time that Mstislav Vsevolodovich had been in Italy and he examined the collections with great interest. When asked if he would care to see something else, he replied:

"There is a certain lady in Milan who has the best private collection of Botticelli's pictures in Italy."

The Italian scientists who were accompanying us, including the art critics, seemed never to have heard of the collection. Our guide immediately telephoned the museum. The Italians could hardly believe what they heard when they were told that the collection did exist and that its owner was willing to see the Soviet scientists.

Thus, even in his passion for art Keldysh was a professional.

At the beginning of the 1970's Mstislav Vsevolodovich's health deteriorated. A venous complaint grew worse, and the Presidium of the USSR Academy of Sciences decided to invite an American surgeon, who performed the operation together with the Soviet doctors and there was a temporary improvement. Keldysh continued to work hard, though he actually required more rest. However, in 1975 his health no longer permitted him to hold the post of President of the Academy any longer.

Stanislava Valerianovna KELDYSH: If Mstislav was not busy on a Sunday, we tried to go out of town and walk in the forest. The children always came with us. He was also an avid gardener and where we stayed in the country he grew roses... He loved nature. When we had guests, he would take them in his car and show them the fascinating scenery along the Moskva river.

He used to return home very late from his office, and used to go straight to his room, where he would lie on his couch and listen to music. Sometimes, he would look through his favourite books of illustrations. This had a soothing effect and made him forget the pain in his legs.

G.M. GRECHKO: After my second space flight I went to see M.V. Keldysh at the Institute. He asked me many questions about the new "Salyut-6" space station and the experiments we had carried out during the flight. I somehow felt that he was not altogether pleased and I discovered what was worrying him. He told me:

"The 'Salyut-6' is a much better station. New possibilities have become available; we must certainly utilize them and widen the scope of our scientific programme. We shall think how to do it. We shall soon have a conference and ask you to join us."

Mstislav Vsevolodovich was a man of his word, and the conference would have undoubtedly taken place had he not passed away.

N. CHENTSOV, D. Sc. (Phys.-Math.), winner of State Prize of the USSR, Director of the M.V. Keldysh Museum:

Mstislav Vsevolodovich is buried in Red Square near the Kremlin Wall.

In the Avenue of the Space Heroes in Moscow, monuments have been erected to Chief Designer S.P. Korolev and the theoretician of cosmonautics M.V. Keldysh. The Space Research Institute of the USSR Academy of Sciences founded on Keldysh's initiative looks out on Keldysh Square through wide bands of its windows. Summer and winter the flagship of the research fleet of the Academy of Sciences "Academician Mstislav Keldysh" plies the waters of the world. On the visible side of the Moon next to the Atlas and Hercules cirques, there is a crater named Keldysh. Within the period of over four years the minor planet "Keldysh" has been orbiting the Sun. Its trajectory lies between the orbits of Mars and Jupiter.

Chapter II.3

THE TAKE-OFF

Academician A.M. PROKHOROV, winner of Lenin and Nobel Prizes: His early life was not much different from that of many of his contemporaries. He was born in a poor peasant family in Krasnoye Selo of Leningrad region, and though the soil did attract him, his passion for mechanisms, machines and radio took the upper hand. He left his village and became an apprentice fitter.

He later acknowledged that the world began to open its mysteries to him only within the walls of the N.E. Bauman Higher Technical School in Moscow. He then served his apprenticeship in the N.E. Zhukovsky Central Aero-Hydrodynamic Institute. He was in the vanguard of those creating new planes conquering the air. At the same time he worked as a fitter, engineer and designer.

The war brought many changes into the lives of people. The new technology he had developed was tested in a belligerent sky. When it became necessary to be an administrator too, he undertook the duty as well.

The end of very severe trials brought the gratification of victory; and his dream to become involved in the conquest of the Universe came true. From then on his life became a circle comprising the laboratory, the workshop

and the test site. It became imperative to bring an entirely new technology into being in a very short period of time. He designed the control system that would serve the Soviet Union's ballistic missiles, spaceships and space probes.

Historical dates were like landmarks in his own biography: the first Earth satellite, the photographs of the far side of the Moon, the flight of Yuri Gagarin, the first docking in space, the first space stations, and the launches to Venus and Mars and so on.

His pupils still work in many of the science and research institutes and design bureaus of the country.

He was called N.A., his initials for his name and patronymic. Less often he was called Chief. Fate decreed that his surname be known to only a narrow circle of people.

For many years our common work and close friendship brought us together.

Academician Nikolai Alexeevich Pilyugin, twice Hero of Socialist Labour, winner of Lenin and State Prizes, was Chief Designer of Soviet control systems; he devoted his life to the welfare of his Motherland.

The More Work the Better

P. SERGEEV: We were once "tinkering" with a piece of equipment in the test area, welding it again and again. At four o'clock one of the women assemblers stopped work and was about to leave. Nikolai Alexeevich was sitting close by with a crowd of officials.

"Where are you going?" somebody asked her.

"My working day is over?" she replied.

"But Pilyugin asks you to stay," someone said.

She remained adamant:

"And who is this Pilyugin to me? My foreman is Zhukov, and he didn't say a word."

"She is quite right, Zhukov is her foreman," Pilyugin broke in. "Now, dear comrade, would you please lend me your soldering-iron until morning?"

The woman looked at him with respect:

"You are an old man and seem to be trustworthy, so you can have it," she said.

Nikolai Alexeevich sat down to work.

We knew that on the day the "Spartak" football team was playing he would leave his office and go home at seven o'clock, that is, as soon as his working hours had finished and that he would not wish to get in touch with anyone of us. Any other time he used to get hurt when someone left the work early... It was not because the person involved did not do what was required, but merely because Pilyugin could not imagine a life divorced from work. He was wont to say: "I was looking for you at eight this evening, but for some reason could not find you." There was no question of a reprimand; it was simply that he was offended, as any of us are.

K. SKRIPOV: Once Nikolai Alexeevich asked me to come and see him and said: "You'll now have to work on rockets of this kind." And so we began working on Korolev's latest designs.

Some time later I reported to Pilyugin: "Everything is fine, Nikolai Alexeevich, but I'm afraid we shall not be able to do everything." He was quite categorical: "Try to bear in mind that it is bad not to have any work at all. It always pays to have a lot of it and have to do it all." I have remembered this all my life: the more work the better.

S. MIKHAILOV, D. Sc. (Eng.), winner of Lenin and State Prizes: There was once quite a debate on the use of computers. Pilyugin was not himself a specialist in the field, but he had a flair for descrying the most essential point in any subject. We should certainly not have been able to apply computers to control problems, had it not been for the support of our Chief Designer.

He was a remarkable person. When the first launch to the Moon was scheduled I was on holiday in Sochi. Pilyugin had no idea where I was, and yet my solitude was intruded by a policeman who came to tell me I was wanted at the telephone station.

The call came from Nikolai Alexeevich: "Listen, Semyon," he said, "the launch will be very soon, and you're on holiday. Wouldn't you be sorry to miss it?" I agreed and went straight to the booking-office only to discover that no tickets were available. However, Pilyugin had said: "I shall settle everything." Several hours later a government telegram arrived and I flew to Moscow. I must say that I have rarely come across a person heading

a branch of technology or science quite as reliable as N.A.

He was quite sure of the people who worked with him. They could think and work freely. He did not spare himself either. He once returned from leave, bringing a notebook with him containing calculations for our new system, which meant that he had done all the theoretical computation on holiday.

K. SEREGINSKY: One day my presence was required at Korolev's offices. Something had gone wrong with the work there.

"You are upsetting all my plans!" Korolev told me. There was a break during the tests, and I telephoned Pilyugin to report on the incident... "Take this block", he said, "and don't leave the workshop until you set everything right and complete the tests."

He was very strict but gentle; we all loved and respected him and worked as he required.

Sometimes it took designers and technologists a long time to agree on problems of reliability or some other problems. In cases like these he would call the two parties into a small room where he said: "You won't leave here until we have all your signatures." This meant that matters which had remained unsolved for months were agreed on within a quarter of an hour. The appropriate decision would often come quite unexpectedly, as an outcome of a collective endeavour.

Nikolai Alexeevich liked to say: "Rockets do not always fly the way we want them to. They can also discourage us..."

Modern technology is highly complicated and it often becomes difficult to say who exactly was responsible for a failure in some unit and what had actually brought it about.

The attitudes of some people who work together could be based on the principle that no one accepts responsibility for what has gone wrong. In this kind of situation Pilyugin adhered to quite a different viewpoint: "Make sure the fault is not yours!" Even when it was an engine that was found to have malfunctioned, he would insist on checking the control system to see if it could have brought about the situation.

We have every reason to say that he was a "dauntless warrior". He undoubtedly enjoyed enormous prestige. Even those who did not like his straightforwardness had to respect him as an opponent, he was known to be thoroughly decent. There were quite a lot of battles being waged; a group working to develop a space technology was only just being organized; the researchers did not always have convergent opinions. New designers appeared with quite new methods of investigation. People were not disagreeing merely for the sake of conflict; the struggle was induced by technology itself.

F. PETROV, Hero of Socialist Labour: He was always well organized and ready for work. Each time he was brought the drawings, he would take his pencil, look at the paper and encircle something, saying, "Comrades, this is no good. Let's do it like this." People usually agreed, though occasionally they argued. His decisions were practically always approved of. He was a wonderful designer, and he was devoted to all that was new in technology.

A. ARUTYUNOV, Lenin Prize winner: He regarded certain questions pertaining to the creation of new products as of the first importance. We had quite a few problems with the multi-layered printed circuit boards since we had only just begun to use them in our designs. At the time they were being manufactured in a somewhat amateurish way and could thus not meet all our requirements. We went to see Nikolai Alexeevich. What was to be done? It transpired later that he took the only correct decision which was to organize a workshop to make them ourselves. We designed the workshop, got the necessary equipment, and, I must say, that for a fairly long time the workshop was one of the best of its kind. Those were the problems the Chief Designer took up.

P. NIKITIN: Over the course of time I had developed my own style of work, and wrote technical assignments for myself. I fulfilled them myself and had no idea that Nikolai Alexeevich was following my work very closely. It turned out that he was in favour of my method, and in order to facilitate a projected assignment he sent me to the test site to see what I had produced at work (it was the launch of the dog Zvezdochka—a little star). After the trip, my work became much clearer to me.

G. GEORGIEV: It so happened that we met N.A. most often at the test site.

Once Pilyugin brought the whole of our team together and ordered us to examine the whole existing setup for safety. Three or four days later he came to see us at the launch site and noticed a substantial drawback—the design was made in such a way that a rocket, having received a ready signal, could be launched prior to the evacuation of the service personnel. He was offered a number of alternatives. Then he said (he used to call me “Zhora from Odessa”), “You try to do it so that I will not be able to find anything wrong, no matter how critical I am.”

We invented a scheme and put the finishing touches to the control panel. It took him some time to examine everything very carefully.

I remember an episode which I later saw in the film *The Taming of Fire*. The consumption of alcohol at the test site was strictly prohibited. We once went to a canteen where N.A. had decided to treat us. He asked the waitress to bring out a bottle of cognac. As soon as we had poured it into our glasses, the Chairman of the Commission appeared: “What’s that?” he asked. “At the test site?”

N.A. could certainly have objected and there would be no problem. But all he said was: “Quite right. Let’s pour it back into the bottle. We have to obey the law.” Then he went to the wash-basin and emptied the bottle.

E. MARYINA, Cand. Sc. (Eng.): I met Nikolai Alekseevich Pilyugin in April 1947 when I was on my student practice before graduation. After I defended my diploma, I stayed to work under his guidance.

He was a great enthusiast. His absorption in his work was so contagious that we did not find anything unusual in continuing to work after office-hours, on our days off, and even on holidays. I remember once on Mondays, N.A. used to bring sheets of paper with meandering formulae, and apologizing, said: “Last night I was rocking the cradle with one hand and writing with the other.” His daughter had just been born.

He could interest people in even the dullest work such as time-consuming calculations, which in those days had to be done manually.

He possessed a remarkable technical intuition and could perceive anything new. For us, both when young and as we grew older, he used to organize lectures, courses and seminars in which such prominent scientists as B.N. Petrov, K.S. Kolesnikov, and Ya.Z. Tsipkin participated.

N.A. was no weakling, and yet callousness was totally alien to his nature. His kind humour and shrewd smile invariably exerted a placating and winning effect upon people under most trying circumstances.

The Launch Begins at the Plant

I. ALEXEEV: I remember we came to see Nikolai Alexeevich with something we had worked out. He looked at the drawings and said: "I'm afraid you've missed something."

We replied: "How do you mean? We have calculated hardness, friction, and what not."

"But," replied Pilyugin, "don't you think that it will be difficult to machine this part and that a special tool will be required? Go and do everything you can to help the machine operator."

At one time he had been a machine operator himself and he could not remain heedless of what might seem a trifle. He also taught us to foresee how a device would function further and take care of it in every stage of its development.

V. KONSTANTINOV, Lenin Prize winner: In the 1950's we started preparing for the conquest of outer space. I was then concerned with cam instruments and had to travel on business practically all the time. Frequently my instruments had to be adjusted 'on the move'. Sometimes Nikolai Alexeevich stood beside me, watching my work. He was supposed to let someone else check the instrument to see whether I had gone wrong somewhere. Instead, he would look at me and ask: "Are you quite sure everything is O.K.?" When I answered in the affirmative, he would sign the acceptance document. He used to trust rank-and-file engineers, which saved us quite a lot of time, and we all felt that we had not the right to make any errors.

When something was not coming out right, he was al-

ways ready to alleviate the tension and calm everybody so that the work could progress.

I remember how sartorially careful he was. During a trip to the polygon a group of slovenly dressed engineers, wearing jackets and rough-ladder boots came to see him. On the first one or two occasions he made no remark. Then he said: "Now, comrades, this won't do. Go and put on something decent, please... and don't forget your ties."

A. ZININ: I joined the collective in 1963 and began to work at an experimental shop where new mechanical instruments were produced. We had quite a few problems with them. Pilyugin used to come to inspect our work three or four times a day. He would ask every worker questions and if something was not coming out right, he would take the drawings and investigate the matter. What surprised us all was that the Chief Designer used to pay attention to every small detail. His ability to remember so many particulars and the whole system as such was no less astounding! He could always cheer up people, which is something that others find hard to do. Another thing that needs mentioning is that he was always polite.

K. ARSENYEV: N.A. was devoted to technology, and was no less fond of industry and its organization. We, technologists, could feel that very well.

He used to begin his working day with industrial problems. At eight o'clock we would visit the workshops and would always ask the technologist to come and see him. I would sit waiting for his call, when he would say something like: "Come to the workshop... the heat-treatment one." Then I would start thinking how he had got there and why? I then found him in a tiny room to hear him say, "Now, look here, technologist, how is it possible to have such a mess as this? Aren't you ashamed of yourself? Just watch this man produce such precise instruments here. You should arrange the workshop in quite a different way and allot him a special part. Why not raise the culture of the industry. And, one more thing... I should like to have your plan of how the situation is to be improved on my desk tomorrow."

The next day he would go to the galvanic workshop and say: "What is this we see here? Acid and water on the floor!" I told him it would be necessary to reconstruct the

whole workshop. "Right you are," he answered, "You are the technologist and it is your job to do it!"

Once he came to the toolshop and addressed the man in charge of it: "Are you through with the draft unit?"

The man said: "Tomorrow."

Pilyugin asked him again: "There's a lot of work there: will you cope?"

The shop superintendent thought for a while and said: "What if I don't? Will you dismiss me?"

Pilyugin answered: "Do you know anyone I have ever dismissed?"

"Well, no, I don't think there are any," was the reply.

People worked late at night and did everything to keep their word.

When we were moving to new premises, he called me and asked if I was planning to go. I told him "No" because I lived close by and got used to the area. Then he sent me to take a look at the new plant. When I saw him again, he asked what I thought. I told him that the plant was good and that the equipment was excellent. I told him I had the impression of having been at some exhibition, though nothing had been done so far. N.A. then asked about the parts we produce. I told him we could cope with the work easily. "Well, why don't we have a go? Come on, we have to go there, it's no use hesitating. But remember, I never force anyone to do anything. A person only works creatively and successfully when he wants to." In the long run he did persuade me to go and work there.

I. ARKADYEV: I first met Nikolai Alexeevich in 1946 when our work was just starting. In those days he paid a great deal of attention to experimental processes in industry and considered that scattered workshops, which we had then, would not meet the demands of a new technology. Mechanical precision instruments were developed on a very small scale, and only later were turned over to powerful workshops.

Pilyugin used to go to a workshop early in the morning and get in touch with those who were immediately connected with precision mechanics. It was the workers whose opinion he valued most of all. He often did not even see the shop superintendent.

He liked to repeat that if something had to be done

in a short period of time, his experimental workshop could always be relied on. The workers had never let him down and did the work on time.

Whenever Nikolai Alexeevich explained something he used to draw the design himself. He would take a sheet of paper, put his finger in the centre and hold the pencil tightly. He could draw circles much better than can be achieved with a pair of compasses. The remainder of the work was executed in exactly the same manner. He was an excellent draughtsman.

People respected him and appreciated his talent as a designer. He was given credit as an ordinary engineer who could speak with workers in their own language.

He Knew Everyone's Character

B. EVGENYEV: I came to work to Pilyugin in 1956. As a tester I was fortunate to be involved in much of the testing, and I began working at the test site at the very outset. Nikolai Alexeevich was there each time a launch took place. I remember how I would come back home from our work, fall on my bed completely exhausted wishing only to sleep well. He would ring up and ask what the programme was for the next day. At eight in the morning he would be there on the spot. He would start asking questions, stressing some aspect of our work, allowing no 'liberties'. Some did occur, and we were punished. Sergei Umov and I were twice 'dismissed' from our job. We thought he would forget his instructions as he had given them in passing when we were in his car, but he remembered them, and he insisted on them being compiled with.

He liked to joke. Once I came to him to have some paper signed. He was busy 'silvering' the water. He signed to me not to disturb him for a while. Then he poured the water into two glasses and drank the contents of one of them.

"Does it help?" I asked him.

"Oh, yes. Especially if you are young and healthy," was his reply!

I. OKULENOK, State Prize winner: Once during the tests at the test site the autostabilizer cut off in the concluding operations. The situation was extremely com-

plicated; time was short; people got nervous, but no one knew what had caused the accident. At long last after a prolonged and careful examination, I discovered that some instruments installed on the top of a hatch, which had been moved while the work progressed, had come into contact with the autostabilizer. After things had been rectified, the flight was a success. During a brief discussion afterwards S.P. Korolev placed the blame on me alone. I was so upset that I did not know how to continue my work. Since it was not "our instruments" that had brought about the extraordinary situation, it was quite unfair to reprimand me for what had occurred.

Nikolai Alexeevich spent a long time trying to soothe me, and Korolev finally said: "Now, don't be angry and let's continue to work together."

P. GORIN, Cand. Sc. (Eng.): In 1947 Nikolai Alexeevich was member of the State Examination Board for one of the faculties of the Moscow Aviation Institute. At the time the "normal" students were presenting their graduation papers. There were also those who were known as "abnormal" students. We got this appellation because we attended various additional lectures while those in the same year with us had already begun working on their diplomas.

The group of 'abnormal' students was the only experimental one and consisted of 11 undergraduates from different groups.

Our classes and the presentation of our graduation papers were on the same floor of the main building and we often stood at the doors of the examination room late in the afternoon, lending moral support to those inside the room. On one such evening Nikolai Alexeevich went out into the corridor and started talking with one of us. Gradually we all became involved in the conversation. He was interested in our plans for the future and at the same time invited us to go to his Science and Research Institute to talk about our graduation papers at greater length.

Several days later we went to see him. He received us in his tiny office, where we again discussed our future scientific topics and agreed to be taken on as technicians at his department.

Today it seems remarkable that when suggesting research topics he sensed the character and ambition of

each one of us. In this respect he proved to be so infallible that even later whether working with Pilyugin at the Institute or in some other organization we continued to work along exactly the same lines.

O. EREMIN: On his desk he had a sign: 'Smoking is allowed', though in the last few years of life, he abandoned the habit. It was characteristic of him that he understood that people had their own specific addictions and meetings often lasted very long.

An illness compelled him to drink a great deal of milk and when someone else was present, he always offered the person some. However, not everybody likes milk, and tea was offered instead. Sometimes the discussions would reach saturation point at which tea served to produce a propitiatory effect and make the atmosphere more homely.

In the 1950's he became fond of photography. He was most interested in the instrumental part. In the first half of the decade he obtained every kind of Soviet camera and he tried each one. He printed very few of the pictures he had taken. Once he was asked to develop all his negatives, and for the first time we saw unique photographs of S.P. Korolev, and so on.

D. PALTSEV, Cand. Sc. (Eng.): Nikolai Alexeevich loved technology. He used to collect locks and talk about his hobby. I once asked him if he had a pneumatic lock. I saw that he was surprised and had to invent something on the spot... "There is a kind of tube," I said, "and you have to blow air into it..."

Some time later he met me and said: "I have to hurry home. My wife has forgotten to take her 'bulb' with her and can't get into the house." It turned out that he had constructed his own pneumatic lock into which one had to "blow" air from a bulb.

S. MIKHAILOV: His was a very modest way of life... When he received a new flat we asked him how it was furnished. He was a bit surprised and said. "Well, I have a bedroom with two beds in it and, of course, a writing desk."

He had no passion for things. The only exception was a sound system. He couldn't boast of having a good ear for music, but his wife, Antonina Konstantinovna, both enjoyed music and had the required background knowledge, and she helped him perceive and appreciate the art.

He was fond of the process of selecting pieces to record and the process of taping them. He disassembled his tape recorders and studied them thoroughly. It should be mentioned that this hobby was not altogether divorced from his work.

E. MARYINA: He had his own way of making rissoles. He liked to prepare them using several kinds of meat. Frying pan-cakes using three pans was also something he enjoyed. In those days there were not more than thirty of us, and so it was not difficult to know what everyone preferred. For instance, Nikolai Alexeevich knew that I was particularly fond of raspberries, and would treat me to tea with raspberry jam.

P. SERGEEV: Speaking of rissoles, he used to prepare a supply for the whole week. On Saturday and Sunday the whole family would help make them. Then he would store them in the fridge so that everybody could have some, even his daughter and grandson who lived in town.

A. ZININ: He was exceptionally modest. My wife worked as a nurse in a dental surgery and used to tell me how Nikolai Alexeevich would wait for his turn to be seen by the dentist. He wouldn't even think of jumping the queue, as certain 'big shots' do, and then were incomparably less busy than he was and yet they would make a lot of fuss, stressing their excessive importance.

S. IVANCHENKOV: In July 1982, his health was getting continually worse. He had already been in hospital for several weeks and yet we reported to him every single day. He did a lot of reading, and insisted on having more books.

On August 2 he died. On that day the rainy eyes of many of us knew neither suppression nor embarrassment.

Chapter II.4

OH, HOW I WANT TO EMBRACE THE EARTH, TO BREATHE, AND SING!

Those days in April when the world's first cosmonaut Yuri Gagarin aboard the spaceship "Vostok" went on his space journey are becoming ever more remote. One of the people crucial to this remarkable victory of Soviet science was

A.M. Isaev, D. Sc. (Eng.), Hero of Socialist Labour, Lenin and State Prizes winner and a communist.

Academician G.I. PETROV, Hero of Socialist Labour: I met Alexei Mikhailovich Isaev soon after the war, by which time he was already an experienced designer, having worked in V.F. Bolkhovitinov's design bureau and helped create the first Soviet plane with a rocket engine. Even so he was still looking and had yet to choose a field. The development of the "BI" plane had only pointed him in a direction. A long path full of difficulties and the unknown still lay ahead.

He was distinguished in those days by energy and optimism. The work did not always go smoothly. There were more failures than successes. Sometimes the engine tests seemed very much like bombing the test site with heavy explosives: test structures blowing up into the air after only a few seconds. But Isaev believed in what he was doing and that it was vital for his country. He believed and inspired others. A characteristic feature was his extraordinary intuition.

The spaceships "Vostok", "Voskhod", "Soyuz", and "Progress", the "Salyut" space stations, the "Kosmos" satellites, and space vehicles which voyaged to the Moon, Venus, and Mars were all produced by A.M. Isaev and those working under him; they were the result of their talented activity.

B.M. ISAEV, D.Sc. (Eng.), State Prize winner, the designer's brother: Alexei inherited many attributes from his father. He was very gentle in personal contacts and yet adamant when it came to achieving his aim. He was impressed very much that in 1915, father went to war as a volunteer, though as an assistant professor of law of St. Petersburg University he had the right to abstain from military service. He fought on the Caucasian front and was in charge of a machine-gun crew. He acknowledged the Revolution whole-heartedly and in 1918 joined the Socialist Academy as a professor.

We lived in Moscow in Pirogovka. Our flat was rather small and we all had to share the same writing-desk. Father, Alexei, and I worked at it in turn. For some time our mathematics teacher at school was A.N. Kolmogorov (the future academician) and physics was taught by

A.V. Faleev (the author of well-known textbooks for school).

Every summer father took us to the Crimea, the Caucasus, and Central Russia. Later, when he was studying at the Mining Academy, Alexei used to travel on his own or with his good friend Yuri Beklemishev (Krymov). This friendship remained strong for many years. On September 20, 1941, Yuri Krymov, who had by that time become a widely-known writer (the author of *Tanker Derbent*) was killed in action.

Alexei had entered the electromechanical faculty of Moscow Mining Academy after secondary school. In June 1930 two months before completing his studies, he was expelled. A large number of educational reforms were being adopted at the time, some far from being reasonable or even necessary. Alexei rebelled against one of them.

As was the procedure at the time the decision to expel him from the Academy was taken by the Trade Union Regional Committee. I think the wording was: 'Expelled from the Trade Union and the Mining Academy for misbehaviour and for hindering the higher school reforms.'

Isaev left for Magnitostroi.

The Joy of Every Day

From A.M. Isaev's letter to Yuri Beklemishev (Krymov), February 24, 1930

"Dear Asparagus,
I am back at the design bureau. Do you remember how emphatically certain I was before my departure never to have anything to do with design. Well, there was no choice, and I had to accept the lesser of two evils. This is how the evil of design has befallen me. Now I suppose, and perhaps it is not a mere supposition, that I am quite happy with my work. Our bureau consists of the manager, myself, one technician-designer, two draughtsmen-designers, not counting two not terribly bright girls and a slow coach of an old man who functions as a copyist. I managed to show them that though inexperienced, I am more conversant with the business

than any one of them, for which reason there can be no doubt that I shall be well provided with the most difficult work...

My main problem today is to find a decent place to live. Until now I have been staying in a kind of hut with a lot of other people. It is impossible to do anything else here but tell jokes. What I really want to do is to take up something, either electrical engineering or English. I'm sure that everything will be settled soon. Tomorrow I am going to see the deputy construction chief and I won't leave his office before getting a room in an hotel. Well, my dear old Asparagus, to call you by your nickname, I'm afraid I have to stop. Please let my father read this letter. I'm sure he'll find it interesting.

Write to me at the following address: Magnitogorsk, Head-Office of Ore-Mining Works, A.M. Isaev (Engineer)."

B. M. ISAEV: Alexei has appealed against the decision to expel him from the Trade Union. On September 12, 1930, the Trade Union Central Committee cancelled its decision and allowed him to complete his studies at the Academy. Isaev worked at Magnitostroi until October 1931. Then he left this job to return to Moscow and resume his studies. In January 1932 he graduated from the Mining Academy and asked to be sent to work at the Magnitogorsk Metallurgical Works. Afterwards he went to 'Zaporozhstal' in the Ukraine, where he took part in the construction of the steel works.

From A.M. Isaev's letter. Dneprostroi, April 7, 1932:

"I am breathing in life itself. I'm 23 and what particular odour my age has. It's really wonderful! And how beautiful the Earth is, with the bright sun pouring upon it and the air fragrant with the melodious sounds of steam-engines, cranes and excavators, which have a more emphatic ring than Tchaikovsky's music.

Let everybody be wearing coats. As for me, I have only my shirt on and am walking about hatless, wishing that I could take off even my shirt so as to embrace the Earth that has become more dry now, to touch the

boiler with my body and breathe, breathe all the time, and sing!

Does it really matter if there is no canteen or lunch-room at the plant if at noon you can take four hundred grammes of rye bread out of your pocket and wash it down with a glass of water?

Is it so bad to be awoken at half past five in the morning by the din from numerous steam-engines, cranes, excavators as the whole building site penetrates into your room through the open window?

What's wrong with pouring the cold water of the Dnieper river into yourself and taking a glass of it so as not to feel so hungry; and after that catch buffer of the train for workers, which will take you and the crowd from the wonderful new town straight to your drawings, brain-teasing problems, shutters, iron and concrete?

Why shouldn't I feel happy when an idea comes to me to design some elevator that would raise the inclined bridge to the blast-furnace—to run to it along the steppe, with the larks singing over the place, where in half a year's time steel galore will be issuing forth. Will I slip while standing at the very top of the blast-furnace that is being built and from the topmost part of it visualize the trajectories of those points that will have me elevate the bridge up to here?

Don't you think that tomorrow, the day after tomorrow, and many more days are still to come! You don't really suppose that within this period I shall only build the plant on the Dnieper river, do you? You are quite wrong if you think that I shan't be everywhere! And do you know why? Because I'm twenty three..., only twenty three!

Isn't it all actually so, my dear?

A. Isaev"

From A.M. Isaev's letter. Nizhni Tagil, March 17, 1934

"My dear peaceful family,
On my days off I usually rest. The other five days of the week are filled with work. During the day it is not very productive since most of the time is spent on

talking to people who come to get advice, instructions and what not. In addition I have to go and see my managers. Then comes lunch followed by a lot of fooling about—and all this is very time consuming indeed! Well, I simply think that we don't know how to organize ourselves and make our time, work and even speech function more efficiently. But... at six in the evening, when everybody leaves the office, I remain in the big building all by myself and my projects find their expression on paper with remarkable alacrity. I sometimes sit till very late at night, and when I leave my office, the watchmen crane their necks in the long corridors, puzzled as to where I could have sprung from at such a late hour.

My chief work here is the construction of the district concrete plant. I am busy preparing the draft and technical designs. The plant will really be very good and I like it immensely. I have put in so much of my ingenuity that I must have outstripped even the Americans. When it is ready, I shall be able to take pride in it, regarding my brain-child as the best thing I have ever produced...

Now I do have a place to live. There are people here with whom I spent the few hours that remain from the time that I allot to my flights of imagination into the realm of construction. They always bring me something to eat when I'm hungry, and when they manage to get something sweet I always get a share of it. We compete in a game called 'cork' and organize various parties. Very often, in fact, we find ourselves childish gleeful and run about the streets at night, roll in the snow, climb the scaffolding and go sledging.

Sometimes our mood in the evenings is rather gloomy. For instance, last night after a long working day we fried potatoes, had tea, and sat silently, each of us thinking what wonderful people we are, how pleasant it is to be together, and that soon we shall separate and might only meet some day on some other building site, and... that this episode would never occur again.

Alexei"



fig. 1. Jet Propulsion Research Group. The foundations of practical cosmonautics were laid in the 1930 in the Soviet Union. G. Korolev is on the left

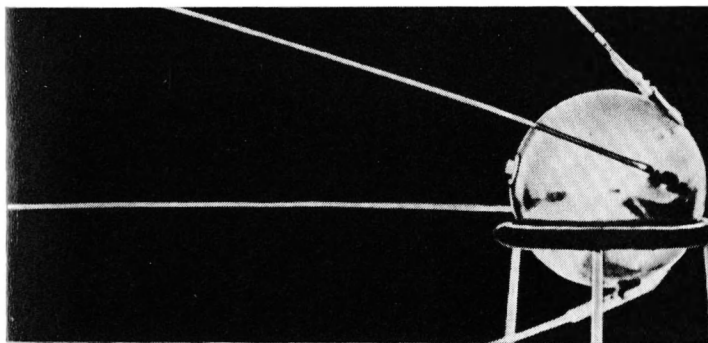


fig. 2. The first satellite. Its "voice" was heard around the world on October 4, 1957



Fig. 3. The Chief Designer for spaceships S.P. Korolev and the first cosmonaut Yu.A. Gagarin

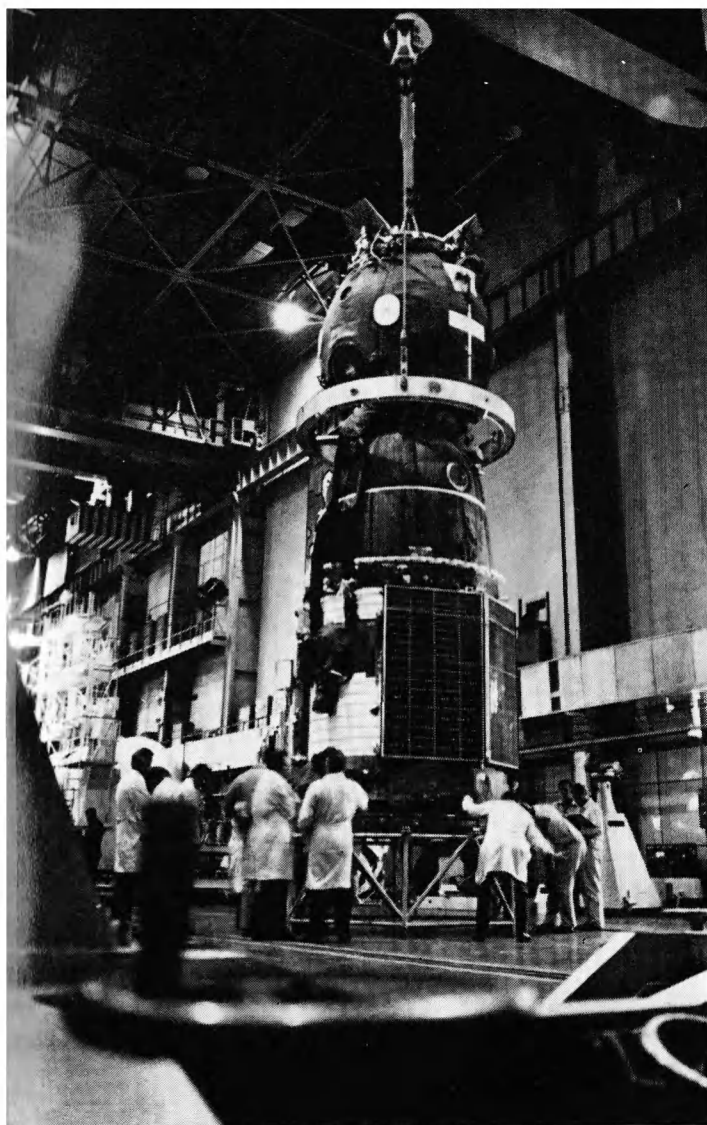


Fig. 4. The "Soyuz" spaceship in the assembly-and-test building (ATB)



Fig. 5. Preparing for the Soviet-Hungarian space mission, V. Kubasov and B. Farkash at the Gagarin Centre for Cosmonaut Preparation in Star City



G. V. Lyakhov and V. Ryumin, long-term inhabitants of
"Soyuz-23".

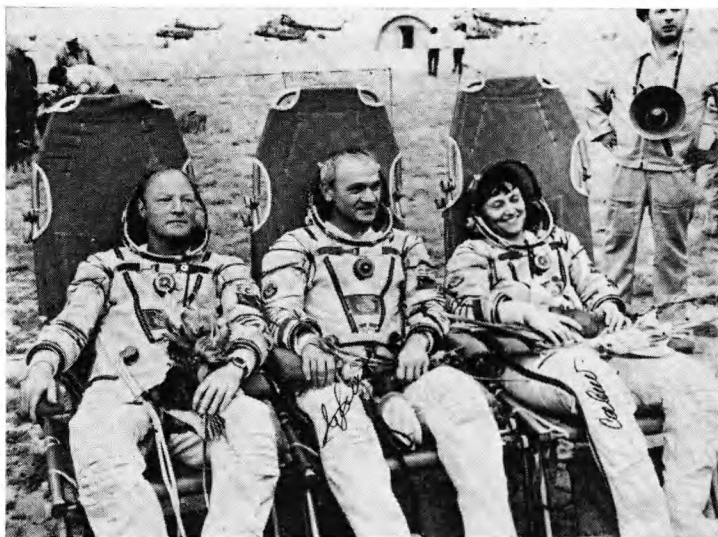


Fig. 7. Women taking part in space missions, S. Savitskaya with V. Dzhanibekov (commander) and L. Volk (flight engineer) after the completion of their mission

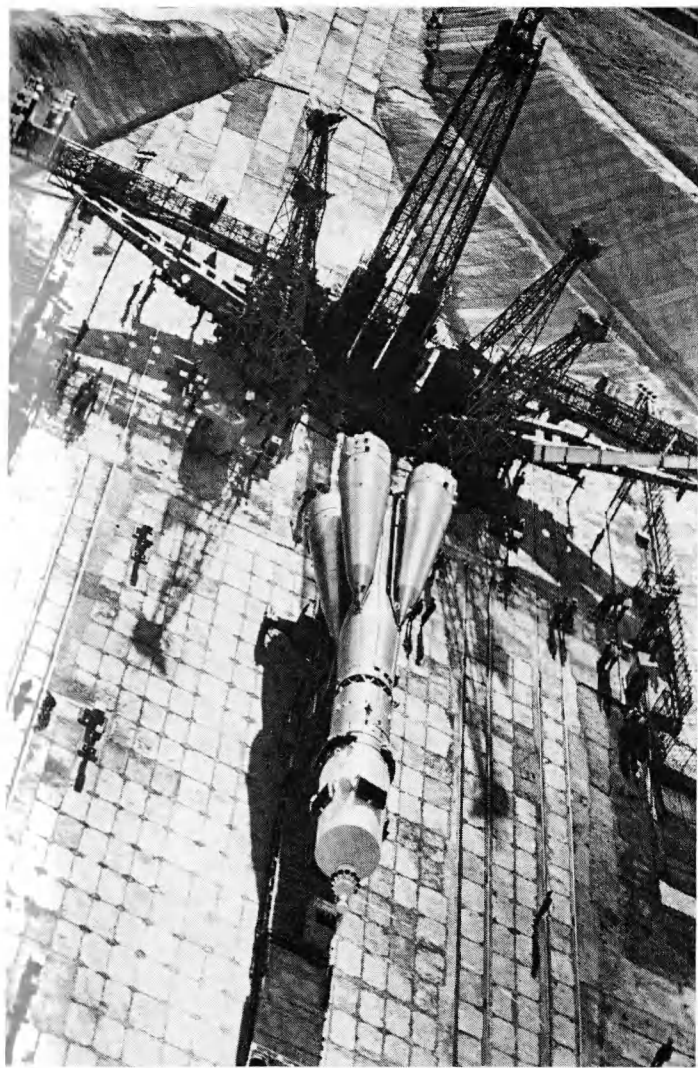


Fig. 8. Launch approaches



Fig. 9. Z. Ien and P. Klimuk on the "Salyut" station. Verifying final components during the Soviet German space mission

"Dear Comrade Director,
Circumstances compel me to address you personally and ask that you permit me work in the field of aviation production.

I have been interested in aviation for a long time and I don't think that I am totally ignorant of it. I can only prove to you that I have a capacity for design if I have an opportunity to work at a design bureau. In any case, is it not worth taking a risk, since, as you know, any progress is made by people who ardently desire to work.

One year will be enough for me to become an aviation engineer and take my place in aviation industry.

I do not desire a large salary nor do I require a flat. I am absolutely free at the moment and can begin my work immediately.

If my letter seems convincing, I should be obliged should your secretary write to me at the address enclosed herewith.

Yours sincerely,
Isaev"

Isaev the Restless

A.A. TOLSTOV, Cand. Sc. (Eng.), Lenin Prize winner: Isaev came to Bolkhovitinov's design bureau in 1934. For the first years we worked in neighbouring teams and our desks stood next to each other. I watched Isaev master aviation technology, which was quite new to him then. My impression was that it did not take him much time to cope with his work. Neither did he make too great an effort or lack confidence. Quite clearly he possessed a comprehensive and fundamental knowledge of technology and a talent of an engineer.

In the early 1930's a research was under way in the USSR on the development of new types of engines for planes and rockets. Isaev was not heedless of this very promising topic.

In 1940 Bolkhovitinov's design bureau was experiencing a 'genre crisis'. It became obvious that nothing which had been initiated remained uncompleted, while the administration of the design bureau were unable to

find new problems. A.Ya. Bereznyak, a former graduate of the Moscow Aviation Institute and who at that time was working at the design bureau, became interested in designing a fighter aeroplane (interceptor) with a liquid-propellant rocket engine. His calculations indicated that such a plane could have a greater rate of climb and be faster than planes with piston engines, which were then being developed. It would be an effective countermeasure to the enemy's bombers.

Bereznyak considered Isaev to be the only person who could collaborate with him on the work and told him about his idea. Isaev liked it and they went on doing the design together. Bolkhovitinov soon noticed that two of his engineers were working on something outside their immediate duties and the two men had to share their secret. Bolkhovitinov turned down the suggestion, but allowed Bereznyak and Isaev to continue their work "in their spare time after office hours".

The war had broken out, towns were being bombed, and the threat of air raids over Moscow made a decision essential. A decree from the State Committee for Defence was issued concerning the mass production of planes with liquid-propellant rocket engines.

At the time the decree was about to come into force a debate typical of such cases raged. The designers asked to have at least six months while the Chairman of the State Committee for Defence allowed them a month.

A.Ya. BEREZNYAK, D.Sc. (Eng.), Chief Designer and winner of Lenin and State Prizes: Our friendship did not require us either to see each other often or correspond. In most cases we could quite well discuss our problems over the telephone and render help, if necessary.

We appreciated each other almost immediately when I came to work under him in the team dealing with mechanisms.

Our joint work on the design of the interceptor, which later (when its drawings were issued) V.F. Bolkhovitinov called the "BI" (the initial letters of my surname and Isaev), had made our friendship even stronger. At first, only the two of us tackled the project. We worked in evenings, on our days off and at night. When the decree of the State Committee for Defence appeared and Bolkhovitinov's factory received an assignment to produce the

plane in the shortest period of time, everyone at the plant worked day and night. The interceptor was designed and constructed in record time. In one month and ten days after the decree came out, the plane rolled out onto the airfield.

During all this period nobody had practically left the plant. People slept at odd moments, when work permitted them to do so. In addition, we had to be on duty on the roof of our enterprise, extinguishing the incendiary bombs that were dropped on Moscow by the Germans who had failed to reach Moscow other than by air. We also had to stop work to dig trenches and defensive dykes, and set up anti-tank 'hedgehogs' and block obstacles.

This is how we lived and worked till the end of October 1941. In the last ten days of October the plant was evacuated to the Urals. During an exceptionally short period of time all our equipment was dismantled and the documentation packed. Alexei Mikhailovich like everyone else rushed about the plant, taking down machine tools, and loading them on trucks and then stacking them on the platforms.

On October 25, our train started. On November 7 we arrived at an old dilapidated pipe foundry plant with neither floors, windows, nor doors. We had to spend the night in the only big building in the village, which was a church, with the floor for our beds. The next day, however, all of us had to unload the train and clean the plant in order to make it ready for work.

Youth and a conviction we were doing something important for the front gave us the enthusiasm, made us ignore the exhaustion, feel elated and never sulk even when things were not coming out right.

Lieutenant-General V.Yu. PYSHNOV, Chairman of the State Commission: Since he knew how the "BI" could accelerate a pilot Grigori Bakhchivandzhi started increasing the angle of ascent. From the Earth the plane already seemed a tiny object, though the torch behind the nozzle continued to shine and at a height of 1500 metres the plane turned. When something like a semi-circle was drawn, the torch disappeared and a reddish smoke began to trail from the nozzle. The active part of the flight was over. About a minute had passed since the engine was

started; now the plane was sliding noiselessly descending slowly to land. The landing was not smooth and the fragile undercarriage was damaged. Since Bakhchivandzhi had not managed to land properly he had no other choice but to 'slide on the wing' in order to bring plane's velocity down.

At last the plane stopped. It was immediately surrounded by a ring of people. The pilot was taken out of the vehicle and carried. Many of us intuitively felt that an event of historic importance had taken place.

YURI GAGARIN, the world's first cosmonaut: If it had not been for Grigori Bakhchivandzhi's launch, the 12th of April 1961 would have never taken place.

A.A. TOLSTOV: It was the beginning of the era of rocket flight. Orders began to come in from the burgeoning new industry.

Isaev's was not the only team concerned with engines. Engine manufacturing was a new enterprise and many people thought it fraught with risk (an assumption not wholly without foundation). The authorities considered it necessary to encourage the duplication of research. Groups working on similar topics were created and began to function. However, in the course of time people became convinced that the duplication was wasteful and the 'competitors' joined our groups.

Isaev did everything to see that 'former rivals' enjoyed full rights in the amalgamated body of researchers. There was no question of 'us' and 'them', or 'old' and 'new'.

A.V. FLEROV, State Prize winner: In 1949 a rumour spread that we were to be amalgamated with the department headed by one Isaev. We had sometimes seen him in the corridors of the Scientific Research Institute. He always wore a shabby leather jacket and a smile played on his lips. His department produced the same awkward impression as he himself did. It was not clear who was the chief and who were the subordinates.

When the changes were to take place, we tried to find out something about him. We heard that he was a 'petty tyrant'. This, of course, made us sad. I then tried to get to the bottom of why exactly he was called a tyrant. It turned out that he had once punished a designer for having designed something without finding out whether the required materials were available. The result was that

they had to be ordered in from outside their own plant, which was very time-consuming. What had particularly infuriated Isaev was the designer's statement: "These problems are not my business. Let somebody else get them!"

The episode produced a very favourable impression upon me. I could not tolerate formality in business matters either. I decided to wait and see what would happen.

One day the telephone rang:

"Are you the assistant head of the department?"

"That's right."

"Do you know that your department is being transferred to us?"

"Yes. I've heard".

"Would you please be so kind as to come and see me?"

I did go, but with a heavy heart. I opened the door of his office and saw a very unusual scene. About ten people were sitting at a big table. They felt quite at ease and someone was even laughing. I didn't notice Isaev at once. He was sitting on one side astride a chair. He immediately came down to business.

"Please, say something about each of the members of the basic team in your department, and don't forget to mention their personal qualities."

I started to mumble something, but gradually, seeing that my listeners were so well sympathetic, I found myself carried along. Not a vestige of embarrassment remained. Isaev's concluding words were:

"Well, we shall manage to get along."

And we did manage to work with him for over twenty years.

V.F. CHEBAEVSKY, D.Sc. (Eng.): I think it was very fortunate for me that when I was still a young engineer I happened to join the team A.M. Isaev himself headed. It was a friendly family of enthusiasts, where the spirit of creativity, efficiency and devotion to the common cause reigned supreme.

We were the builders and the cleaners of the builders' refuse. There wasn't a single event in which Isaev would not personally take part. Moreover, he let somebody else keep an eye on the work, while he himself would get hold of the tray, work with the spade or load the barrels, girders and cisterns.

We all worked in a friendly and joyful atmosphere.

On one Saturday when we voluntarily worked without pay ('Subbotniks') Isaev was told a researcher from another science and research institute was waiting to see him.

"What's the problem?" Isaev asked, "Let him come here!"

Several minutes later an imposing gentleman with a mackintosh over his arm approached Isaev. Greetings over, Alexei Mikhailovich heard out what interested the man, and then he said: "Now, hang your coat on that branch, take the tray and let's discuss the matter while we work."

The other person had no other choice but roll up his sleeves. For about two hours they carried refuse, now and then stopping to draw something on the sand with their sticks, occasionally arguing, discussing things and lifting their tray again.

I don't know what conclusion they came to, but I still remember them parting very warmly, and the guest smiling pleasantly and quite satisfied with the outcome of their talk. The expression on his face revealed no wounded feeling at all. At that time he must have been thinking of how he would go back to his office and tell his people there how he had personally contributed to the construction of the experimental basis for Isaev's design bureau.

V.P. MILENKOV: I think that the most striking feature of his character was activity. He was not only restless when designing, which was his main concern, but also when he was on holiday. He liked to joke and was always ready to come up with something ingeniously funny.

I remember dropping in at the managerial department of our Ministry to get authorization to stay at a sanatorium. Isaev was also there on the same business. It turned out that we were going to the same sanatorium, though I was supposed to be there two days before his arrival. There was one more person with him whom I did not know. We left the Ministry together. When we were parting with him, Isaev said to him: "Well, see you at the seashore. We'll try to give you a good welcome."

When the man left us, he said to me,

"Do you know who he is?"

"I'm afraid, I don't."

"Well, he has the same surname as our Minister. He works as a dispatcher at the plant, and is also going to holiday at the same sanatorium. Look here, I've got an idea. As soon as you get there, spread the word that the Minister is coming shortly. Only mention the name. And don't make any joke about it. Just say it in a matter-of-fact way, but make sure that the staff and the administration learn of it."

I understood what Isaev meant and did everything accordingly. The sanatorium staff had not the slightest doubt when two days later Isaev arrived there himself and confirmed my words. The more so that he had a long-distance call from the Minister, and everyone there knew about it.

So they started taking the spare beds out of the de luxe suite, and bringing in carpets and flowers. Floors were given an extra polish too. Everything was beginning to look spick and span for the arrival of the guest of honour.

One should have seen how heartily Isaev laughed at the sight of a scene worthy of Gogol, when the whole 'retinue' came out to pay tribute to the 'Minister'.

"Well, how did they fix you up?" we asked him the next day. "I must say that I was given a royal reception."

He knew who he had been taken for and to whom he was obliged for the lavish amenities. We were all happy that the joke had proved so successful.

Several days later we heard other guests saying something like:

"Do you know that the person in the de luxe suite was received as a Minister?"

"But isn't he the Minister?"

"Oh, no. He just has the same name!"

It didn't take long for this news, which had also originated with Isaev, to reach the ears of the staff. Then both the guests and the staff were all laughing, the only difference being that the former laughed at the latter, while the latter laughed at themselves.

L.A. PCHELIN, Lenin Prize winner: At one time I worked at another design bureau. There each designer was given a task and a date it was to be completed. If he managed to do it in time, he would receive a bonus, if not he lost the bonus. The extra money was issued monthly and the sums were not small. When the assignment

was finished, the drawings went to the control group where errors, if there were any, were classified into eight categories. The first included deficiencies that did not impair the drawing itself; for instance, an incorrect frame size or an irregularly placed stamp. At the entrance of the building in which the design bureau was located hung a board on which the designer's name and all the faults in his work were enumerated. Thus, if the unit you had designed was not satisfactory, and if you wished to improve it, you took the risk of being late with the assignment, and there was no question of any bonus. If you hurried and went one millimetre wrong in measuring the frame of your drawing, you would soon find your name on the list of slipshod workers. Hence, there was no point in trying to 'surprise the world'. It is not difficult to assess the quality of a drawing, whereas it is practically impossible to evaluate an unprecedented unit.

At Isaev's design bureau things were different. Unrestrained and friendly, the whole atmosphere was conducive to creativity. The work was interesting and presented no special difficulties. Isaev possessed the outstanding gift of encouraging every one of his researchers. When giving an assignment he would never set any rigid time-limit for it to be completed. If the work was urgent he used to say, "Now, step on the gas, the work had to be finished yesterday lunch-time". But when a designer saw that he had not done his best and there was a way to improve things, he used to tear the drawings off the board and throw them into the wastepaper basket. In such cases Isaev would not get angry; he would simply ask: "What on earth are you doing?"

"Well, Alexei Mikhailovich", the designer might explain, "I was not very happy about it, and I'll have to do it all over again."

"And how will you do that?" This question was usually followed by a serious discussion during which new designs would be generated in our minds.

No Right to Err

K.K. KOVALEVSKY: I am a graphic artist and I was usually asked to draw technical placards for well-known designers.

At about four o'clock in the afternoon when my working day was coming to an end, I was told to do three placards by the next morning. My boss said, "Isaev himself requested the work". Half an hour later Isaev came and brought sketches of the proposed placards. The work was enormous and I had only a single night.

Without wasting a minute I combined two Kuhlman drawing units and began work. The hands of the clock seemed to move mercilessly and with extra zeal. It was nearly midnight when Nikolai Ivanovich Kalinin, the night shift captain, told me that Isaev had arrived. After looking very thoroughly at the placards, he cautiously and in an embarrassed sort of way offered me a bundle, saying: "This is something to keep you going." The bundle contained butter, caviar, cheese, bread and two bottles of beer. When Isaev saw that the work would be completed in time, he left the office, with me standing there perplexed. In the morning he thanked me for the work I had done and wrote down my telephone number. A week later I was asked to come and receive a bonus.

K.V. ADIANOV and A.D. SLASHCHEV: We went to Isaev's establishment to prepare for the tests of some new industrial products. On the eve of our departure Isaev telephoned and said that his car would be waiting for us at the station.

The car was there and we reached our destination in practically no time. A conference was already taking place in Isaev's office.

As soon as we reported on our mission, we were taken straight to the workshop, and, by the end of the day, all the preparatory work for the tests was completed. We informed Isaev and said that we had to go and find a hotel, and that early in the morning we would be ready to begin work.

"Why do you need the hotel? Here are the keys to my three-roomed flat. I think you will find it is large enough," he said, handing us his keys and a slip of paper with his address.

We really didn't know what to say and started waving our hands in protest.

"Oh, no! Alexei Mikhailovich, please don't!" we said.

"And where will you find a hotel at this hour? My flat is empty because everybody is in the country and I'm

going there myself now. I'm sure you'll have no problems. You'll find the bed linen and the blankets and I hope you'll have a good night's rest, so as to be quite ready to work in the morning."

His arguments were irrefutable and we had to agree.

It didn't take us much time to find the flat, which turned out to be as unpretentious as its master.

S. IVANOV, *Hero of Socialist Labour*: Sergei Pavlovich Korolev trusted Isaev implicitly, and Isaev appreciated the attitude. All the assignments were done in time, never evoking any unfavourable criticism. It was, therefore, no coincidence that Isaev's design bureau was asked to design the engine braking system for the "Vostok" spaceship. This vessel had not only to put the first cosmonaut into orbit but also bring him back to Earth. If there were a single flaw in the braking system the vehicle would either remain a permanent captive of the Universe or would burn up in the atmosphere. Besides, while automatic devices could be duplicated (or made to use different circuits), the "Vostok" design did not allow for spare braking engines. Hence, Isaev could make no mistake.

On April 12, 1961, Yuri Gagarin made his historic flight...

Chapter II.5

THE FLOWERS OF BAIKONUR

We should speak of Yangel so that every word sounds like the melody of a rocket being launched. A colleague of the Chief Designer said these words, and indeed M.K. Yangel's life had much in common with the popular song of the thirties: 'We have been born to make our dreams come true, to overcome the vast expanse of space...'

About Yangel

Even though at the age of nineteen he had a steady job as a textile worker and could support himself like an adult he nevertheless continued to dream of aviation. He had no doubt where he wanted to study: the Moscow Avia-

tion Institute. It brought him closer to the realization of his wish.

His graduation paper, which he defended five years later, in 1937, was directed towards the future. It was called 'The high-altitude fighter with a pressurized cabin'. His scientific adviser was aviation designer N.N. Polikarpov, whose P-5 planes rescued Chelyuskin's expedition from the polar ice, while the I-16 was considered to be the best fighter of the thirties. Valeri Chkalov and Vladimir Kokkinaki made their record flights in Polikarpov's planes. Yangel considered Polikarpov's design bureau to be a school of the art of engineering and collective endeavour. This was when Yangel's character was developed; he became a perspicacious designer and inflexible person. Together with those who worked under Polikarpov, he saw both success and the black periods of failure and ordeal.

Yangel always tackled the most difficult work, the tasks stated by time itself. He pioneered a new field in Soviet space-rocket engineering. He worked side by side with S.P. Korolev, N.A. Pilyugin, A.M. Isaev...

M.K. Yangel was an outstanding scientist, a talented designer and the founder of a new trend in rocket science and technology. Under his guidance the first rocket-carriers and satellites, the "Kosmos" and "Interkosmos" series, were created. On his sixtieth birthday his pupils wrote:

'This day is remarkable not only for you personally, but also for the large family of your pupils with whom you have spent the best years of your life.

On this arduous path you have lavishly given us a part of your intellect and your vast experience. We must thank fate for having vouchsafed to us the opportunity to work with you—a wonderful person, indefatigable worker, a man of principle and high demands, strict and yet kind to us—your younger colleagues. All we have done over our years with you is inseparably connected with your good name...'

The Soviet people were greatly appreciative of M.K. Yangel's achievements. He was made twice Hero of Socialist Labour, winner of Lenin and State Prizes, and was a member of the USSR Academy of Sciences and the Academy of Sciences of the Ukrainian SSR. He was

also a deputy of the Supreme Soviet at several convocations.

This year Mikhail Kuzmich would have seen his seventy-fifth birthday. His untimely death came at the age of sixty.

With Love as a Constant Value

The following extracts have been borrowed from M.K. Yangel's letters to his wife I.V. Strazheva and her own reminiscences.

*May 15, 1938**

"The weather was so bad that we lost our way in the fog and landed at Los Angeles airport four hours behind the schedule. I have a few wonderful images. Millions of electric lamps scattered over a great area produce the impression of a starry sky, while my imagination produces a scene of a flight in interplanetary space—something that thrilled me years ago. The fast moving cars lit by the floodlights of the vehicles coming behind them involuntarily make you think of the future spaceships. And the rays of those lights seem to be the traces of these ships in the Universe. Don't you think it's a ridiculous fantasy? I am sure you cannot even imagine what an incorrigible dreamer I can be."

October 7, 1939

"... I don't quite understand how you can divide love and our customary attitudes to each other. The fact that I have become used to you finds its only expression in that it reveals ever new feelings towards you, giving them more weight and making them more profound.

The habit of which you speak is a very dangerous thing. Where people base their relations on habit alone there is no love, and they never knew love. Suffice it for someone else to ignite one of the two who have become 'accustomed' to each other with a spark of love or simply passion, and their life, founded on habit,

* Santa Monika, California. M.K. Yangel was visiting aviation firms in the USA.

disappears into thin air... Sometimes men think that they can conquer the heart of a woman by showing her indifference. I can express my sincere feelings only as far as my intellect allows me without either belittling or exaggerating them artificially. It may sound not terribly clever, but it is at any rate honest."

November 9, 1939

"My very dear Irinochka*,
I am missing you awfully though only a day has passed since we parted. In mathematical terms I can express it like this... The force of my attraction to you (F) is proportional to my love (L) with a coefficient (x), which is a function of the time of our parting $x = \varphi(t)$. If certain assumptions are made, and my love for you is taken to be a 'constant' (which is not the case since it increases all the time), the expression would have the following

form: $F = L \int_0^n x dx$. When we part for twelve days,

$F = 72L$, for fourteen days the expression is $F = 98L$... I don't know what sort of infatuated dreamer could think of expressing his misery of being away from his loved one in a mathematical formula."

December 11, 1939

"Our life can be fraught with anxiety, but to overcome all these difficulties, we shall need each other more, raising our love to a greater height, and making our life more joyous and eventful. And when we look back at it in many years to come, we shall have the right to say to our children that we have not lived in vain."

September 29, 1940

"Darling, I am sending you my warmest congratulations on the birth of our daughter. I can hardly find words to express my joy that all your sufferings are behind and the little angel is with us.

* The Russian pet-name for Irina (Irene)—*Tr.*

Today I have bought a gift for her. It seems to be a good perambulator; one of those that were on sale at the department store in the centre of Moscow. It looks nice and the price is quite moderate. It is standing in my room, and I am thinking how I shall take our little girl for her very first 'promenades'.

Please write and tell me how they are taking care of you and the baby. If something goes wrong, I'll kick up a fantastic row."

August 17, 1942

"... I am writing this letter sitting at the desk in my study. The hand of the clock is moving towards midnight. Things at work are getting better, though the problems do not seem to get fewer; the most difficult are connected with the gruelling and time-consuming process of training personnel. Quite recently I have managed to restructure the whole administrative organization and the workshop itself. Problems inevitably cropped up and I am not quite sure that everybody was pleased. But it is not the time now to take into consideration the wishes of those who either don't want to work or who lack proficiency. Therefore, there is no reason why they should continue to hold the posts that at one time or another they obtained by chance. The front is in need of planes.

I'm becoming ever more sure that I shall accomplish the work assigned to me, and with this conviction I am becoming more firmly assured that I am helping destroy the invaders..."

*September 16, 1942**

"Excuse me for the tardiness in answering your letters. I set the blame entirely on my work. The plant where I am working is in the making and the people here have not yet become accustomed to it. Hence, there are quite a few deficiencies in managerial and technical matters. I have practically no days off.

At first all those in charge of the workshops and other sections of the plant seemed to be on a kind of military

* From a letter to his mother-in-law V. Rusetskaya.

footing without the right to leave the plant, as though it were a barrack. Now, however, we have got permission to alternate night duty with our assistants (I have two), and, probably, in a month or so we shall be able to come home every day."

September 20, 1942

"It's my day off at the plant, but it does not mean that I can rest. As early as 7.45 in the morning I received a Party assignment to cut wood at the Snegiri railway station (do you remember we used to pass it on our way to our country house in Istra?). Last year Snegiri was occupied by the Germans for nine days, and one can still see the traces of battle, to say nothing of the grievous memory that the fascist sojourn has left with the local people.

My lumber day did not prove successful. In the first place, it rained mercilessly from nine o'clock in the morning till the very end of the day, and I got soaked through. Secondly, when we were felling the trees one of them nearly fractured my leg, but fortunately I got off with nothing more than a fright. However, the most saddening experience was that we did not fulfil the plan of six cubic metres. So we'll have to go there once more. I returned home after nine in the evening, cold and hungry.

Now I feel a bit better and am drying my suit...

In all other respects I continue to work at the plant in the same way. These last ten days in September will show how right I was in restructuring the workshop's work. I have already written to you that I was given a very difficult programme and that I don't know whether I can cope with it or not. For the last twenty days I have not been able to make the workshop follow the schedule. I hope to do much better in the period that is left..."

November 6, 1942

"For goodness sake don't think that I didn't write to you because I had no wish to do so... I simply have so much work to do that my head is going round, and by

the end of the day I am completely exhausted, while the work is progressing very slowly. Neither I nor any of the other shop-stewards have any assurance that we shall be able to work according to schedule in the coming three or four months. In spite of the changes that have taken place at our plant (we have a new director now) I don't see any tangible modifications in the organization of our industrial process and no improvement in the living conditions of our workers. On the contrary, with the cold weather coming, people are getting ill more often... and I am horrified at the thought what may happen in December and January..."

November 8, 1942

"... Quite unexpectedly, on the eve of the November 7 holiday* I was able to return home earlier than usual (at nine in the evening). I was so happy to find a letter from you. I see that you have become upset now that you know more about my work. Don't worry about me, darling. My work is really difficult, but it isn't hard as all that—I'm accumulating experience for the future.

On the sixth of this month I managed to have a bath and by 12 o'clock p.m. I was at Savely place. He, his brother and I were discussing Stalin's speech and we were about to turn in when Savely's sister, who lives in the same house, rang and asked us to have supper with them. There I met Stakhanov..."

November 23, 1942

"... It was Sunday yesterday and I had to work as usual. I came home as early as eight in the evening. You can't imagine how glad I was to see your envelope in the letter-box while I was still in the lift.

Please don't feel hurt that I am not writing to you often. I can't write at home since it was beastly cold (down to -6° C), and it is a problem to write letters at my work. I have three of my letters to you lying here

* The anniversary of the Great October Socialist Revolution—*Tr.*

before me. I have not been able to finish any of them since there was always something that prevented me from doing so for a long time. Later, however, they seemed to me to have lost their novelty."

April 3, 1945

"My little darlings,

I am missing you awfully. I wish I could lift you up very high and see if Sasha is brave enough, and as for Lucy, I already know that she certainly is, and even more so.

Quite recently the Big Bad Wolf paid me a visit and said that Lucy and Sasha were very naughty and were not obeying their mummy and grannie.

Now, look here, my little ones, if you continue to behave in this way, the Big Bad Wolf will get terribly angry and there will be no presents for you when I return home.

Please write to me, take good care of yourselves and ... behave!

Love, *Daddy*"

*October 5, 1945**

"At present I am the head engineer at an experimental plant, i.e., where the first prototypes of new planes are developed and constructed. My immediate duty is to supervise the design work and coordinate any activity, including the solution of the technological problems that crop up when a new plane is built. The work itself is fairly interesting, and I think there is no reason for me to feel dissatisfied, though I am not quite sure if everything will come out just as has been planned."

August 1, 1952

"That I have not written anything to you until now is entirely my fault. The rate at which the days pass is very much the same as that of a rocket fighter. Hardly can I find time to think of something personal when the week has already gone. All the days after your depar-

* A letter to his brother P. Yangel.

ture have been very strenuous. There is no alternative but to do the work in July as best as possible. Much has already been done. The output plan has been fulfilled 120 per cent, but that of the range of production remained unaccomplished. In this respect August will be even more difficult. However, Korolev was pleased with our work...

I feel quite fit, though dead tired. Last Sunday I went fishing but my catch was only enough for fish soup. To crown my not very successful endeavour I lost my identification card, which meant that I had to write to the Minister himself. Today they informed me that I was to receive a duplicate..."

August 18, 1954

"There may be some who will be surprised to know with what enthusiasm I have taken up the new trend (M.K. Yangel was appointed Chief Designer of rocket-space technology), but I am really fond of broad assignments, and feel how much experience and knowledge are required.

... It's the second week that I have been here, and I already have my first impressions and some idea of the people, the conditions of life and work and the city itself. These are the things I should like to write to you about. The situation at work comes first. I was welcomed as someone long expected. In spite of all this, it will not be easy to work here, particularly at the beginning. The primary reason for this is that there are not enough people, and especially qualified people to do the work that I am supposed to organize here. There is practically no way to take on the required staff and I shall have to fight tooth and nail to get what's necessary."

November 21, 1955

"... Quite involuntarily, and not for the first time I keep asking myself why did I decide to live away from my family? To serve the people, to be useful to my Motherland—but this is not merely the duty, but the meaning of life itself. I have lived with this idea in my

mind ever since I started my conscious activity without having any conflicts in my private life. Who was it who determined that in my forties I should find a more propitious place in life for myself precisely in this domain? I have never been ambitious and have always been quite content with the thought that I am doing something from which my people can benefit. What force then has driven me here? Please don't imagine that I am sorry for the choice that I made. No, things are not as bad as all that, and I suppose I shall never regret it. I raise all these questions merely because I want to express how sad and lonesome I sometimes feel without my family, and what a pity it is that we are not together."

July, 1958

"We are preparing for the tests. I am rather well, though I can hardly bear the heat. It is morning now, but the temperature in the shade has already gone up to 30 °C. We expect to have forty or even forty five during the day. The conditions are tiresome, but what really counts is the work we are doing. Each launch is exhausting in the extreme, and yet I am convinced that the country really needs it for its security, assuredness in its future, and new scientific and technical progress."

Besides Rockets

... I am often asked about the relations between Yangel and Korolev. What I can say is that they were not close friends. In their attitudes to each other—both personal and professional—there prevailed a spirit of creative competition, though there was certainly a clear understanding of the responsibility each had to their country and the people.

September 1965. After a prolonged important collation of their draft plans, the two academicians had a day off. They decided to spend it together at one of the resorts outside the city on the bank of a very quiet steppe river. When the white motor-boat was approaching its destination, the one in charge of the holiday camp said:

"Your piers are close to each other: one bungalow is for Sergei Pavlovich Korolev, and the other is for Mikhail Kuzmich Yangel."

While the anglers, who accompanied the Chief Designers were preparing their bait and lines, Yangel and Korolev walked along the bank of the river by the path leading into the shade of trees.

"Let's have a short talk about our work," said Yangel.

They did talk, though not as briefly as they had planned.

"Discussing rockets?" asked one of the anglers when Korolev approached.

"Both Mikhail Kuzmich and I remembered when we measured where the center-of-gravity of a plane was," said Korolev, "we used to roll loaded barrels into the plane from the nose and then back again. So we were wondering whether we could apply the same method to rockets..."

"No shop talk, please," said Yangel.

Then Korolev, pointing at the two boats near the bank, said:

"Shall we have a row?"

"You are not afraid to lose, are you, Sergei Pavlovich?" asked Mikhail Kuzmich slyly, "Suppose I leave you behind?"

"Well, I'm not afraid to be the loser here," said Korolev, looking at the still water in front of them. Then he raised his eyes to the sky and said: "But not there, in space!"

Yangel reached the opposite bank sooner.

"You, Mikhail Kuzmich, were brought up near the bank of a river, while my childhood was spent near the sea," was how Korolev summed up the situation. "I bet you wouldn't win if it were a scow race."

"You bet me?" asked Yangel, "Well, I accept the challenge and am quite ready to compete with you in any activity and run any race. Don't you think it's interesting and useful for our common cause?"

"And do you know what I've been thinking of now?" said Korolev with a smile. "I thought that you and I were the two banks of the same powerful river!"

... Nikolai Alexeevich Pilyugin, Chief Designer for control systems, used to make peculiar little boxes out of the foil from cigarette packs, which became famous in the

history of cosmonautics. The longer a regular conference lasted, the higher the mountain of boxes in front of Pilyugin grew.

"The conference lasted twenty-five little boxes," Pilyugin would often sum up the proceedings, "though I think that ten of them would have been ample."

Pilyugin loved music. He would listen to records of folk songs and popular music for a long time. He would always have a tape-recorder and a set of cassettes with him, when he came to see us at our country house.

"And what shall we have first," Yangel would inquire, "control actuators or 'Dark Eyes'?"

"Music rejoices one's heart, when the head is no longer crowded with problems," Pilyugin would imperturbably express his opinion.

However, as was often the case, they often did not have enough time for 'Dark Eyes'.

"Control is our nervous system itself," Yangel often used to say. "And what better qualified 'outer space neurologist' could one find than Academician Pilyugin. He has never had a problem and task he could not cope with..."

"What about the five questions," Pilyugin reminded him self-critically.

What Pilyugin had in mind was when a neighbour's boy, who was then in his first year at school, once came up to the academicians while they were having a break.

"Could you please help me make up five questions to this problem?"

"Why five, when two will be enough?" asked Nikolai Alexeevich after thinking it over for only a couple of seconds. "Two questions and the problem is solved."

Yangel came to the same conclusion.

"But the teacher said we must have five questions," said the first-former with a sigh.

The academicians tried hard to meet the demand of the school teacher only to acknowledge their defeat. Some time later Pilyugin said that he had given the same task to the designers in his computer department and only one could cope with the assignment. It turned out that his son was also a first-former and that he had previously consulted the school-mistress.

... Academicians Yangel and Artsimovich did not of-

ten see each other, but when they did they were really happy to shake hands again.

"Scientific research invariably implies the satisfaction of one's own interests at the expense of the State," was Artsimovich's standing joke. He used to supplement it with the question: "And how is it with your technology in this respect?"

"Rocket technology," Yangel would reply, "presupposes a total neglect of one's own interests for the sake of the State."

At first Yangel used to call Artsimovich a 'millionaire', then a 'billionaire' and then a 'trillionaire'. The last of these three titles was conferred upon Artsimovich from the moment when he told Yangel that tens of billions of volts could no longer meet the physicist's demands for the acceleration of elementary particles and that a more powerful accelerator was now called for.

"You mean trillions?" asked Yangel to confirm what he had just heard, and from that time on the physicist was called a 'trillionaire'.

"Shall we begin with a ride in the 'Mooncar' or with a discussion of how we shall build a 'unique sauna' on Venus at some time in the future?" Those were the questions with which Yangel would usually meet our frequent guest Georgi Nikolaevich Babakin, under whose guidance many of the space probes to the Moon, Mars and Venus were developed.

They liked to talk about space studies, first-nights at the Vakhtangov theatre, and music. While they were discussing things, Yangel's grandson Sergei was impatiently waiting for the end of their talk behind the door.

"Excuse me, but I must make some telephone calls," Yangel would say to Babakin.

Leaving the study Babakin greeted little Sergei with the following words:

"Well, what shall we play? Hide and seek?"

"But no spying on me! O.K.?"

"My word on it," was Babakin's reply.

After finishing his telephone calls, Yangel would shake his head disapprovingly:

"Again you're making all that noise..."

"Even the ancient Greeks rationally combined their mental activities with athletic games..."

"Well, it is like this, Georgi Nikolaevich..."

After that both Babakin and Yangel would start squeezing themselves behind the book-case with the result that next morning the downstairs neighbours invariably had the same question: "Were you moving furniture in your flat yesterday?"

... The relations between A.N. Tupolev and M.K. Yangel were very friendly, though 'black' days did sometimes intervene.

"A little bird told me that Yangel was using Comrade Illyushin's plane for official purposes," said Tupolev to Yangel while they were on their morning walk at the sanatorium. "I couldn't imagine you doing a thing like that, Yangel."

"Were you really offended?" asked Yangel who was upset with what he heard.

At the open-air cinema that evening Tupolev was not at his usual place close by Yangel's seat. Tupolev had taken his whole family to the opposite side of the auditorium. But the following morning 'diplomatic relations' were restored during a talk they had under a spreading plane tree.

"We have settled everything," said Yangel to me later. "Tupolev recommended his new TU-134 plane and I have fully supported this idea, which will be implemented without delay."

... Regular guests at our house included Valentin Petrovich Glushko, Boris Nikolaevich Petrov, Alexei Mikhailovich Isaev, and Mstislav Vsevolodovich Keldysh. There were days, hours, and sometimes only minutes, when the wrinkles would disappear from the brows of the scientists and their eyes would start sparkling merrily. There was the usual bantering, 'shaggy-dog' stories, and with their grandchildren in arms they would go swinging. They would also discuss such problems as how to plant fruit-trees with the ardour of genuine gardeners. Then they would rack their brains over the construction of a chimney for a samovar. In addition, they were fervent supporters of their football and ice-hockey teams, and expressed their joy and frustration watching games on TV.

However, such moments of rest were rare.

I remember how my husband once came to the sanatorium and said:

"There are so many things that I have to do, but the testers let me go for some time so that I could stay with you all and do a bit of angling."

The telephone rang on the following day and he was told that the presence of the Chief Designer was urgently required at the cosmodrome. That evening our son and I saw Mikhail Kuzmich off at the airport in Simferopol.

"Everything is fine: I did see you and had a swim in the sea. And as for the fish, let them grow a bit more," said Yangel when we parted.

"Your husband is one of those people who do not belong to themselves," said a man who was also seeing him off. He said this to console me, looking at the plane as it was gaining height.

Chapter II.6

THE MACHINES OF THE TWENTY FIRST CENTURY

Academician K.V. FROLOV, Director of the Institute of the Science of Machines of the USSR Academy of Sciences: The life of A.A. Blagonravov is a reflection of a whole century. He was born before the Wright brothers made their first flight and just after A. Popov began his experiments that led to the discovery of radio. Nevertheless, the scientific interests of Anatoli Arkadyevich Blagonravov in his later years included research on outer space and the study of the stability of atomic reactors.

He was born on June 1, 1894 in the village of Ankovo of the Suzdal district in the province of Vladimir. In spring 1903 he entered the Vladimir gymnasium for boys. After nine years he completed his studies and received a gold medal. This gave him the opportunity to continue his education at the St. Petersburg Polytechnical Institute. However, the First World War prevented him from realizing his plans. After a short period of study at the Mikhailovsky Artillery School he continued his career on the Caucasian Front.

In November 1917 Blagonravov was promoted to sub-lieutenant, which in itself had no significance for him at all. Since 1918 he had found himself in the ranks of the Workers-and-Peasants Red Army, fighting in the legen-

dary 'Iron' division. And yet when he did become a regular officer of the Red Army, he never stopped thinking that his aim in life was engineering.

To strengthen the defence potential of the country it was necessary to develop new types of automatic weapons for the infantry in a very short period of time. This task required a large number of specialists. Blagonravov became engrossed in this activity. In 1930 he was appointed head and the only lecturer in a new department of small arms at the Military and Technical Academy. He was also working on his book *Fundamentals of the Design of Automatic Weapons*, which has now become a classic of scientific literature. The graduates of the department put the ideas of their teacher into practice. This proved to be highly profitable since the war was nearing.

The group elected to full membership of the USSR Academy of Sciences that included professor Blagonravov was outstanding. He shared the honour with I.V. Kurchatov and A.N. Nesmeyanov, while A.P. Alexandrov, M.V. Keldysh, and A.A. Ilyushin were elected Corresponding Members of the Academy.

Blagonravov's scientific interests widened. In 1951 in collaboration with S.P. Korolev and V.I. Yazdovsky he was involved with the launch of the first vertical take-off rocket carrying research equipment and two animals. The newspapers did not write much about those launches since they were the very first steps.

Under his guidance the foundations of the automatization and robotization of Soviet industry were laid. For more than twenty years Anatoli Arkadyevich Blagonravov headed the Science of Machines Institute of the USSR Academy of Sciences.

His country evaluated his merits very highly. He was twice honoured with the title of Hero of Socialist Labour and was a winner of Lenin and State Prizes.

With His Thoughts in the Future

E. GERTS, D.Sc. (Eng.): I first met Anatoli Arkadyevich when he came to our Institute. He was appointed the head of the laboratory where I worked.

The laboratory was situated in a large room part of which was occupied by the welding tool we were trying

to automate. We were told we would be having a new manager. We had had quite a few and did not expect the new one to meet us earlier than a week later.

However, when I turned up at nine o'clock on the following working day, I saw the door open as I was taking off my coat and a slender gentleman walked in saying, "I am your new head of the laboratory." It was something quite out of the blue. The usual chatter ceased and one of the women who entered the room right after Blagonravov, on hearing these words, trembled awkwardly and trod on the new manager's toes. Someone giggled, but the rest of us were silently expecting things to develop further. There was something in the air that seemed to strain the situation. And then all of a sudden Blagonravov burst out laughing, quite naturally and easily. We all laughed together with him. Nobody felt embarrassed any longer. After that Anatoli Arkadyevich suggested that we should say something about ourselves and was the first to speak.

Thus there was more unexpectedness. As was customary under the circumstances, we decided to let Blagonravov have the best place near the window where there was more light. We had just started to clear the desk when Blagonravov said: "Please, remain where you are. I shall have the spare desk."

"But," we said to him, "it is in the corner where there is practically no light."

Anatoli Arkadyevich was adamant. For almost a year, as head of our laboratory, he sat at that desk.

It did not take us much time to see that although he was kind and gentle, his attitude to work and discipline was uncompromising.

He was meticulously punctual and it was even possible to check one's watch by him. Our scientists, who were accustomed to a certain lack of discipline, were obliged to change their habits quite radically. The most remarkable thing was that the productivity of scientific work under the circumstances did not drop, as the pessimists had predicted, but steadily increased.

After one occasion the laboratory people opened their hearts to him forever.

A plant in Leningrad asked us to develop a pneumatic actuator for a welding unit. The aim was to facilitate work with it and to make it safer.

However, the management of the Institute had for some reason decided that pneumatic and hydraulic actuators were not promising. Hence, the subject was intended for discussion and scientific research was not actually to have been conducted. As soon as Blagonravov got to the bottom of the problem, he demanded that the discussion should stop and that research immediately initiate. The management tried to argue with him, but very soon gave up.

When Blagonravov became Director of the Institute of the Science of Machines, he continued to guide work at our laboratory as well. Although he and the laboratory were on very friendly terms and our researchers never failed to do what was required of them, he was never biased towards our laboratory, which in fact was even 'underprivileged'. A new equipment was first distributed among the other scientific teams at the Institute, before being allotted to the Director's own laboratory. This is not typical nowadays.

A. BESSONOV, D.Sc. (Eng): A.A. Blagonravov was extremely particular when it came to the ethics of scientific research. Once two members of the Institute, whose research Blagonravov had supported, decided to name him as a co-author when preparing their results for publication. When Blagonravov learnt about it, he called them into his office and reproached them. At the end of the discussion he repeated that he had made no contribution to the work and that by helping them he had merely done what he was supposed to do as the Director of the Institute. He suggested that the two researchers should go and continue their work. This lesson was not lost on other members of the laboratory. Anatoli Arkadyevich was never again made any 'benevolent' offers of this kind.

Blagonravov possessed the remarkable gift of being able to sense everything new and progressive in science. He gave a propitious start to a number of promising pieces of research. However, it should be mentioned that he had never regarded it *infra dignitatem* to acknowledge that he was not always right.

I remember the time I began to indulge in walking mechanisms. There were as many difficulties as one could possibly imagine. It was necessary not only to design a

mechanism that would be able to walk, but also to learn how to control the structure so that it could move purposefully and efficiently.

Initially Anatoli Arkadyevich regarded such mechanisms as far-fetched and of no particular avail.

I asked him to let me speak to him about the work. I entered his office and began to tell him the difficulties we had in designing a walking mechanism. I also showed him some of the draft sketches of the locomotion systems in various insects. I spoke for nearly two hours. I left his office without Blagonravov saying anything. This made me feel very sorry. However, at the earliest meeting of the Scientific Council Anatoli Arkadyevich, mentioning my work, said: "I was wrong in thinking it to be useless. There are quite a few interesting problems and we shall certainly work on them."

Academician A.A. Blagonravov was respected by scientists from many countries, quite a few of whom he corresponded with as friends. He was invited to various international conferences, symposiums and congresses.

Once as a member of a small delegation of three people he went to the USA to attend a congress on the study of the climate and the Earth's atmosphere and stratosphere.

Those were the 'cold' years of the fifties in international relations. Therefore, it was not surprising that the arrival of a small, though high ranking delegation from the USSR was only mentioned in the last pages of the newspapers with a headline such as 'Three Reds Have Come'.

The Soviet report was on the possibilities of studying the climate using rockets. As might be expected the report caused a sensation that reached dramatic proportions when the news came that on 4 October 1957 the first satellite had been launched from the USSR. It was a triumph for the Soviet science.

The visit of the small delegation was then headlined in every big paper and articles were on the front pages.

Even then it was no secret that Blagonravov was associated with the launch of spaceships.

Anatoli Arkadyevich was very polite. At one symposium he met Norbert Wiener, a prominent scientist in cybernetics, and after the meeting all the participants went to lunch. When they reached the door they stopped. Wiener politely asked Mister Blagonravov to go first, while

the latter offered Wiener to do so. The 'traffic jam' continued until someone said, "It would be better for Mister Blagonravov to accept since Wiener is considered one of the politest men in the United States." When the Soviet Academician eventually managed to persuade Wiener to go in first someone shouted: "Blagonravov must be the politest man in the world."

A Man of Principle

Yu. EFREMOV, a worker: Before I came to the Institute of the Science of Machines to work under Blagonravov I had worked at several academic institutions and under quite a few directors and academicians.

What impressed me even when I first met him was his emphatic handshake. He shook hands with absolutely everybody, irrespective of their rank. Both the laboratory assistants and the mechanics maintained an attitude of amiable heartiness towards him.

When someone was in trouble, he would invariably ask Blagonravov for advice. Once I found myself pressed for money and went to the Trade Union only to discover that they had none I could have. I told Blagonravov who simply asked: "How much do you need?" Then, seeing my embarrassment, he added: "Take this. You can give it back when you find it convenient."

If we received an urgent assignment, he did not ask us to see him about it, and did not demand that we work without rest. He trusted his workers and knew that they would not let him down.

The severest punishment for a person was when Blagonravov said: "You know, I am not happy about you."

He was kind, though his attitude never bordered on familiarity. He invariably remained a man of principle.

V. LYUTSAU, D.Sc. (Eng.): As is typical of any designer, Blagonravov had a particularly good visual memory.

Once he was brought a paper to sign. He gave it a cursory glance, made several criticisms, and asked for changes. While the authors were thinking how his criticisms could be incorporated, Blagonravov left on a mission for a month and a half. One of the authors suggested that

they make no alteration to the document since Blagonravov had so much work to do that he would not remember it.

Several weeks later Blagonravov was back at work. On the following day the same document arrived on his desk waiting to be signed. In five minutes "the guilty parties" found themselves in the director's office. He repeated his criticisms verbatim and was very surprised that they had done nothing about the paper for one and a half months.

It was not his memory alone, Anatoli Arkadyevich simply lived for the interests of the Institute and its people.

He was very considerate to the personnel. For instance, when the Institute was reorganized, it was decided to "transform" the departments into laboratories. Thus, each head of a department became a chief of the laboratory. There was no problem except that in the department headed by Academician I.I. Artobolevsky, the laboratory was in charge of the director. This would have meant that Artobolevsky would have remained without "portfolio", so to speak. The situation was quickly rectified. Blagonravov saw Artobolevsky and said: "Well, under the circumstances, you must take my laboratory."

The decision could not have been easy for the man who had worked at the laboratory for a long time and was on friendly terms with its members.

The following episode may also serve to illustrate Blagonravov's consideration.

The director's conference was in progress and Blagonravov presenting a report. Although many of those present agreed with his conclusions, one researcher had a diametrically opposite point of view and contradicted what the director had said. Blagonravov tried to give forcible arguments, to persist his opinion. Agitated by the debate the lady interrupted Blagonravov and raising her voice started attacking him. Instead of an open discussion, a row seemed in the offing, and the usually reserved Anatoli Arkadyevich put a stop to it by saying quite firmly: "Please be quiet! It would be the best thing for all of us."

The questions were all eventually discussed and the meeting came to an end.

The person who had incurred the Director's wrath cooled down and realized she had spoken in haste. She

even began to cry. Suddenly the telephone rang and Blagonravov was at the other end: "Excuse me, please. I must apologize for having lost my self-control. It was my fault."

She said later that she finally succeeded in doing what she had been unable to do that day.

Consideration Above All

A. CHICHINADZE, D.Sc. (Eng): Blagonravov always encouraged young scientists and helped them to start working on their own as soon as possible. I think that many of those in charge of laboratories today shared this experience and my own story is not the exception.

I worked at a factory and sometimes came on business to the Science of Machines Institute, with which we had very close ties. I met Blagonravov several times at the conferences. I once ran into him at the entrance to the Institute, face to face, so to speak. He greeted me and asked how the work was getting along on problems the factory and the Institute were cooperating over. I told him but without going into detail. That was all we had to say to each other on that occasion. Some time later I was told that he was looking for me.

When we met, he suggested that I should defend a candidate's dissertation at the Institute. To be quite frank, I did have some interesting scientific results, but somehow I had not given any thought to defending a dissertation. However, he was insistent: "You are ready to defend a degree."

After I defended my dissertation, he offered me a job at the Institute. In the middle of the fifties this was a problem, and he had to get special permission to take me on. When his first attempts failed, he persuaded higher authorities that my transfer was necessary. That was how I found myself at the Science of Machines Institute.

Age and Anatoli Arkadyevich were incompatible. He was practically never ill, always active and full of a "joie de vivre".

On one occasion he went to South America to a COSPAR (Committee for Space Research) meeting. At the end of one strenuous day the participants were offered a trip in a national park. The conference organizers

added that a riding horse could be arranged for anyone interested. The scientists laughed at this suggestion, but their laughter grew even louder when Blagonravov said, "Why not?" At that time he was in his seventy fifth year!

Someone tried to stop him, he was after all the Vice-President of the Committee, but they did not know him well enough. He deftly jumped into the saddle and gracefully rode along the road in front of his astonished audience, as if horses were his only pursuit in life.

A. *BLAGONRAVOV*: My father was not hard to please. He never thought of conveniences and avoided any comfort. The atmosphere to which he had become accustomed and in which he felt at home was that of a library full of books. This was his world. Shelves with books that were given to him by the authors. Fundamental works on mechanics, aerodynamics, theory of machines and mechanisms, and armoury. There were also novels by famous writers in many languages. George Simenon's work occupied a special shelf. Father had a perfect command of French and could read them in the original. His English was not as good as his French, though he had occasion to speak in London and New York without an interpreter.

He paid great attention to my own education, involving me in the professional work of a designer. As soon as I left school he advised me to take up a military career. "The situation in the world is so disturbing...", was what he said.

The war broke out. I studied at the Artillery Academy. We all wanted to go to the Front rather than to study. The only consolation was that the syllabus was shortened and the second year was the last one. After that we all received our order. Practically all my fellow-students were assigned to military factories as representatives of the Headquarters in the rear. This was called by the situation itself. It was then that I asked my father to help me be sent to the Front. He asked me: "Have you thought it over?" I answered in the affirmative and got to the Volkhov Front.

After the war our home was bereaved of my mother, who, while on holiday in the Caucasus had mishandled a desk lamp and had been electrocuted. My parents had

met during the Civil War and she had been his support over all those years.

Both father and I liked our secluded walks. We were often accompanied by his favourite dog Tsigan (Gypsy). Tsigan was a "cosmonaut" in the sense that he had been taken several hundred kilometres above the Earth, and after the successful return found his home under my father's roof.

Father spoke very little about his work, space launches being top secret in those days. I had no idea that he was now fostering Yuri Gagarin as he had done in my case years before.

S. DOBRYNIN, *D.Sc. (Eng)*.: Erudition and professionalism enabled Blagonravov to take the floor at any forum quite spontaneously.

On one occasion A.A. Blagonravov was to speak at a prestigious international conference in Moscow. Several days before it opened he was asked over the telephone to attend an organization committee and have his report approved. Anatoli Arkadyevich attended.

A committee member looked through the text of his report and suggested that Blagonravov should alter the basic theme of his report. Seeing that Anatoli Arkadyevich remained silent, the committee member hastened to assure him that there was no need to worry since he still had nearly two days and had thus enough time to introduce the amendments and then he need do nothing but read the text in public.

Blagonravov looked at the man and asked: "And in what way would you like me to take the floor, like a horse, a sparrow or a nightingale?"

"What can you possibly mean by that?" asked the surprised man.

Blagonravov answered: "The horse keeps standing with its head lowered while it eats all the oats in the bag. The sparrow looks round after each peck, and goes on like this all the time; while the nightingale takes a high note and lets it soar uninterruptedly. I think that at a conference of this kind with hundreds of scientists from all over the world, it would be much better for me to speak with no restraint, like a nightingale and not like a horse. I shall speak without any prepared text. What I have written here is only for you."

Later it was said that Blagonravov's speech was one of the most interesting at that conference.

Blagonravov kept a constant eye on the work at this Institute. He did not restrict anybody's creative activity, but he tried to see to it that all the research was conducted in the main stream and in promising directions. He believed that this kind of attitude would ensure success. However, he was not against competition in science and would often say: "Consideration above all."

We thought that he enjoyed a robust health. He was a quintessence of assuredness, calmness and force. And when he was suddenly taken to hospital, we thought it was not for long.

For twenty one years he was always earlier than most of the Institute and would go up the old stairs to his second floor office. "The Institute," he was wont to say, "is my life." After his passing the Institute did not part with his memory and adopted the name of Anatoli Arkadyevich Blagonravov.

At the Firing Positions

From the reminiscences of A.A. BLAGONRAVOV: When I was four, I learnt to read. My first lessons (the alphabet and the way letters make up syllables and words) were given by my mother. I became deeply involved in this kind of activity, and as soon as I could get hold of books or newspapers, I tried to recognize the printed words. I think that I must have started to read fluently quite soon and on my own.

In 1901 my mother started preparing me for the entrance examinations to the gymnasium. She gave me lessons several times a week and taught me Russian, arithmetic, and the catechism. My mother thought that a very good way of developing one's memory was to learn poetry by heart, and she made me learn very many verses. There must have been something in it. Now I come to think of it, I really had a very good memory in my childhood and youth.

The time-table at the gymnasium started with assembly in the class-room at 8.40 a.m. and from there we marched in pairs to prayers. The first lesson began at nine.

The most important subjects were Russian and arith-

metic. They were taught by our form-master A.V. Kazansky, a severe disciplinarian and an irascible teacher. He never failed to penalize us for any offence and we were all very afraid of him.

Sometimes the minor violations of discipline we concocted were quite innocuous. For instance, when the Maybugs emerge, we once disrupted the morning prayer before class. Some of the pupils in the back rows tied small bits of paper to the beetle's legs and let them fly to the open windows at the other end of the hall, which delighted all the pupils present.

Smoking was considered a serious offence, to say nothing of alcohol. Transgressors were, as a rule, expelled.

I applied for admission to the Electrical Engineering Institute, to the mechanical faculty of the Technological Institute, and to the ship-building department of the Polytechnical Institute.

The latter was suggested after I read the curricula of the higher educational institutions. The ship-building department appealed to me as soon as I discovered that its students had to do compulsory practice first at the sea ports, then at factories, and finally at sea itself, one of the routes being Odessa-Calcutta-Ceylon-Vladivostok. All that I knew about the sea came from books I had read and the idea of sailing seemed to me both interesting and intriguing.

Since the Polytechnical Institute was the first to inform me that I had been admitted to its ship-building department, I decided not to test fate any longer. I arrived in St. Petersburg before 1 September 1912, and I was received warmly by my mother's uncle.

The Institute was situated on the outskirts of the city and every morning I had to get there first by tram and then by a steam locomotive which pulled three carriages along a narrow-gauge railway; it was part of the city's public transport system. Two of the carriages were roofless and the cold wind blew so freely that I used to arrive at the Institute quite frozen. The nasty part was the soot discharged by the locomotive.

The undergraduates enjoyed great freedom. I knew several 'perennial students' who must have studied at the Institute since almost the day it was founded. The only limiting factor was a set of 'minimums'—after the

first and third years of study. Any student who failed to pass the minimum was unconditionally sent down from the Institute.

The examinations could be taken at any time and in any order. Another feature of our Institute was the absence of any system for grading students. Whereas at university or other educational establishments the marks were 'excellent', 'good', 'satisfactory', and 'unsatisfactory', at our Institute a student either 'knew' the subject or 'not'.

... After a short stay in Sverdlovsk, our battery was sent to reinforce the artillery of the 24th Iron division, the organizer and the first commander of which was comrade Gai.

It was there that I witnessed a 'psychological attack' by a part of Kolchak's army. The only memory I have of the attack was that the officers were very good target for precision fire. Our infantry did not waver, the battery and infantry together repelled the attack.

In May 1920 our division was ordered to the Polish Front, which became very active. The Whites had captured Kiev and occupied almost the whole of the right bank of the Ukraine and part of Byelorussia.

The combat for which I was awarded the Order of the Red Banner was the battle at the village of Soldyrev. I arrived at the firing position of Lunin's battery right when the communication line between Lunin's observation post, which was a long way forward, and the firing post was cut. I went forward of the battery and discovered that ranks of Whites were moving towards us whilst our infantry was retreating to the right flank. There was no one between the battery and the enemy. I ordered our men to get ready with the machine guns and took charge of the battery. The battery opened up with intense fire. The enemy continued to advance and at one point I thought that it was time to retreat as the enemy was getting close. Finally, the enemy could not resist our fire and their attack was broken without the aid of our infantry, which, after pulling itself together, went on to counterattack and the battle was won.

Thus, I became a student of the Military and Engineering Academy, and after sending a telegram to Raya (Blagonravov's wife), I started looking for a room.

However, after about a month I was allotted a small room at the hostel. The management of the hostel was in the hands of its inhabitants. A committee was elected to see to the distribution of living space. The rooms, in fact, did not cost anything, but we had to pay for the services of the cleaners. For three years running I was a member of the committee and was responsible for collecting the money and paying the women, doing some primitive book-keeping. The Academy's administration had nothing to do with the hostel. On each floor we had a common kitchen, with what seems to us now very primitive kitchen facilities. We all lived in a sort of 'commune'.

V.G. Fedorov (a famous Russian arms production authority) did not welcome me warmly and tried to evade the responsibility for supervising my diploma paper. However, being a responsive person by nature, he could not turn down my insistent requests.

At that time he was wholly involved in the creation of smaller-calibre automatic weapons, and suggested that I should include this idea in the diploma paper, which finally was called 'A Project for Adopting the "D" Machine Gun to Cartridges with Improved Ballistics'. Degtyarev's automatic rifle, which was later better known as the RPD became standard army issue in 1927 and was at that time 'top secret'.

I defended my diploma project quite successfully.

... On the morning before Gagarin's flight, as I was leaving my hotel I was 'attacked' by several Italian reporters who said that they had heard that a Soviet pilot was at that moment in space (it was in Florence at the time of the regular COSPAR meeting). One of the journalists even named the cosmonaut, which sounded like a mispronounced form of Gagarin. All I could tell them was that I didn't know what they were talking about.

The sensation came on the next day when the news was released that after a one-and-a-half hour flight round the Earth the first ever cosmonaut, a Soviet pilot, was in good health and back on his native soil.

Professor Lapira, the Mayor of Florence, virtually burst into our room with all the effusiveness of a true Italian. Having delivered an official address, which was very expressive, and with much gesticulation, he said that a

meeting was to be held that day in the Town Hall and would I take the floor.

When I relieved myself of the amiable captivity of the reporters, I started preparing a report and rendering it into Italian. That evening the medieval building of the Town Hall was packed. Trumpeters dressed in costumes of the sixteenth-seventeenth century played an anthem. The concluding words of my report, 'Let us wish, then, the world's first cosmonaut Yuri Gagarin great success and every happiness for many more years to come', were received with overwhelming applause. After the meeting we walked to our hotel accompanied by a crowd of exultant Italians.

Chapter II.7

THE MAN WHO BROUGHT VENUS CLOSER

About My Colleague

Academician O. BELOTSERKOVSKY, winner of Lenin Prize: Georgi Nikolaevich Babakin came to cosmonautics fairly late. By that time the remarkable group of designers including S.P. Korolev, N.A. Pilyugin, and A.M. Isaev had already been formed. This was when both satellites and human beings such as Yuri Gagarin, Herman Titov, and Alexei Leonov (who made the first space walk) had been in space. Georgi Nikolaevich was assigned to guide research on interplanetary probes which were to storm 'distant space'. Humanity was approaching the Moon, Mars and Venus.

His first success came with "Luna-9" which made the first soft landing on the Moon. It was a test for all the researchers, and newspapers all over the world published sensational photographs of the Moon's surface.

Almost every one of Babakin's experiments, which were conducted on a massive scale could be labelled 'The first in the history of civilization'. The unmanned "Luna-16" brought lunar soil back to Earth, "Luna-17" delivered a Mooncar, which traversed the Moon's surface and accomplished a unique series of investigations.

Babakin's design bureau did not ignore Venus. As far back as 1967, when the lunar programme was in progress,

"Venus-4" released a descent vehicle into the planet's atmosphere.

On August 3, 1971 Georgi Nikolaevich passed away. It was a tragedy that he should die before his fifty-seventh birthday and still in the prime of life, and as enthusiastic and energetic as he was.

His contributions were richly rewarded by the nation. Georgi Nikolaevich Babakin, a Corresponding Member of the USSR Academy of Sciences, was honoured as a Hero of Socialist Labour, and was awarded Lenin Prize.

Babakin always thought of the future, and was forever dreaming of new and interesting launches. His design bureau continued to solve the most complicated and crucial problems. "Lunokhod-2" was sent to the Moon. For the first time both black-and-white and colour pictures of the Venusian surface were sent back and its soil was analyzed, probes were sent to Mars, and the time will come when one will rendezvous with the mysterious Halley's comet.*

On November 13, 1984 the Chief Designer of space vehicles G.N. Babakin would have marked his seventieth birthday.

His Striking Enthusiasm

A. RAZIKOV, engineer: At fifteen Georgi Babakin completed seven years of school, which was then considered secondary education. It was 1929 and his family did not have a large income, so he had to learn a profession to enable him to work. He unhesitatingly decided to take up radio engineering. So he and I both joined the courses for radio-technicians organized by the Central Radio Laboratory of the Society of radio enthusiasts.

We were obsessed by a desire to study. Everything was absorbingly interesting. It was only there that we understood that we knew nothing about radio in spite of some amateurish success that we had previously attained. However we had acquired some knowledge, we felt terribly strong and we were eager to assemble radio circuits, adjust and test them. Once we even managed two or three

* This planned mission was carried out with brilliant and startling results—*Ed.*

conversations with our own feeble transmitters. Each session began with a telephone call to say we would be going on the air, tune your set.

After we completed our studies Georgi and I were taken on by Radio Moscow to help on drama broadcasts and the transmission of congresses and conferences. Those were happy days; we had always found ourselves at the heart of current events.

Seven years later Georgi sat for examinations as an external student and graduated from secondary school. He became an undergraduate (he took a correspondence course) only a quarter of a century after he had become an acknowledged authority on automation and radiolocation instruments.

"Work comes first," was Babakin's maxim.

M. RAIKOV, designer: During the war Babakin worked on a system of remote control.

After the Americans tested their atomic weapons, Babakin found himself involved in work on an anti-aircraft defence system. There were those across the ocean who were already anticipating the third world war. The time had come when only a single plane supplied with an atomic bomb could do more harm than one thousand planes before.

It was about then that Babakin and Korolev first met. Having studied Babakin's project of anti-aircraft control complex, Korolev said:

"He is very talented!"

Although the project was never implemented, Korolev remembered the meeting.

It was important for Babakin's future career too.

At one time there was talk that Babakin's design bureau would be converted into a branch of Korolev's bureau. It was assumed that Babakin would be allotted 'distant space', or the development of a station that could fly to the Moon, Mars, and Venus. Korolev was most emphatically against such a reorganization. He considered any branch to be no more than a subservient body, which to a certain extent was deprived of independence and, consequently, of any responsibility.

Shortly after that Korolev went to see Babakin. Several researchers brought a pile of rolls with the designs of stations to be launched to the Moon and Venus. He spoke

to Babakin's people in his normal accessible manner and pointed out the difficulties involved with the research on the planets and illustrated his presentations with the drawings he had brought of the possible interplanetary space vehicles. He also expressed his regret that no tangible results concerning the Moon had so far been achieved. In conclusion he said:

"What you are getting now is an independent field of work and I am letting you have all the documentation without even a control copy for myself. I trust you and I will answer for your results."

He interrupted himself and addressed Babakin:

"Georgi Nikolaevich, please look through this material very carefully and make corrections where required; you will have our suggestions quite soon. Complete the work yourself, please, and if you need our help, we shall certainly do all what we can."

Babakin answered in his customary way:

"Everything will be all right, Sergei Pavlovich..."

B. RAUSHENBAKH, Corresponding Member of the USSR Academy of Sciences, winner of Lenin Prize:

Sergei Pavlovich Korolev was extraordinarily generous; he shared his research with absolutely everybody. I could mention several outstanding designers Korolev discovered. One was Georgi Nikolaevich Babakin. Korolev's attitude to these people was always exceptionally well-wishing. After providing them with a topic for research, he would never mention his affinity with the subject, even when it turned out to be very successful. Quite the contrary he invariably reiterated the word "they" and continued to help the people without pressing them even indirectly.

Babakin tried to get to the bottom of a new topic as soon as possible. I remember when he first visited the Centre for the long-distance space communications. He was astonished by the enormous dimensions of the antennae up to which he went in a lift and then for a long time climbed up vertical ladders as if amongst the sails of a ship. Babakin was surprised to see long rows of boxes filled with electronics; it delighted and inspired him.

When the time came for us to report to our authorities about the results of the experiment (I was then concerned with the "Zond-3" station, which was to photograph the

back side of the Moon that is invisible from the Earth and which had not been photographed by "Luna-3"), I asked Babakin to accompany me and feel the general atmosphere of the proceedings.

We arrived at the meeting and when we were asked who would take the floor, Babakin rushed to the blackboard and started to explain the features of the experiment. I sat there, smiling. I thought it terribly funny that instead of my official report, the audience was presented with Babakin's extemporaneous and unofficial account of something which, on the whole, he had nothing to do with at all.

Why did this happen? The answer is very simple. He saw the technology, understood everything, found his way into all its intricacies, and the whole thing had become his own. He felt it so close to his mind and heart that he could hardly notice that he exceeded his powers and started reporting about the work that did not belong to him. Later, I understood that if there was some event, a talk or speech that had stirred him, he would wait for no turn to come up with his own ideas "on the subject". If someone else's work interested him, and he got to the bottom of it, he did not consider the work alien to himself.

The most interesting thing about this episode was that none of those present at the meeting felt Babakin's speech to be out of place. His genuine enthusiasm astounded the whole audience and won its favour. I was really surprised how a person could so speedily and profoundly acquaint himself with something new and difficult.

Setting About Daring Tasks

A. PLATONOV, winner of the Lenin Prize: Babakin always had a great number of ideas. A probe could be ready or partly so when an idea would come to him. Sometimes somebody would 'inspire' him with suggestions. Improvements of this kind threatened to upset the planned schedule. It was necessary to stop oneself at the right time. Babakin did not always manage this. It was then that the management interfered with their rigid maxim that 'Better is the enemy of what is good'. At first Babakin even complained that his plans were thus impeded,

although he understood that there was no alternative. This made him proscribe any alternatives just before the work reached completion.

It was a severe blow, and he had to be the first one to take it, since he had never demanded any exclusiveness for himself. If others were not allowed to do something, he did not grant himself permission either.

He had the gift of inspiring those who were in charge of projects as well as those working on them. He never banged on the table or raised his voice. He trusted his colleagues and thought all he had to do was to explain to his people the importance of the task they were working at and expect them to do it properly. I remember how Babakin immediately took up the idea of having a competition at the design bureau. The next day an order was issued:

"In order to draw the attention of inventors and those concerned with implementation to the importance of reducing weight while maintaining reliability, quality and function:

1. A competition on weight reduction of the product will be organized;

2. Special bonuses be issued with... roubles per reduced kilogram in the launching stage, and... roubles per reduced kilogram of re-entry module."

It had been estimated that each extra kilogram of rocket returning from the Moon to the Earth was 'more expensive'.

Sometimes people say that Babakin was born genius. Perhaps they are right, but it should be emphasized that he maintained his talent by arduous work.

V. ARKHIPENKO, engineer: One of the probes had to be sent to Baikonur to prepare it for launch. All the units comprising the space vehicle had been checked at the plant but one device was still being tested in compliance with a special ancillary programme. All of a sudden I was asked to go and see my manager:

"Until the tests are over, you must write in all the progress reports that you do not agree to this vehicle being sent."

I was at a loss, and began to explain that I was quite sure of the successful completion of the tests and that it would be better to prepare the probe for launch before

the tests were complete. The manager rejected my suggestion.

I could do nothing but wait and lose precious time. It have been better to do otherwise, i.e. to prepare the station for the launch at the cosmodrome itself where the results of the tests would be sent in good time.

I couldn't wait any longer and went straight to Babakin, knowing that he would always support a daring idea.

"We shall settle it now," said Babakin with some confidence. He telephoned my manager and told him what he thought, which was, naturally, what I suggested. Then he added:

"I have not the slightest doubt that everything will be all right. In the long run we can solder the thing together again, if necessary. The only obstacle," Babakin winked at me, "is your representative! He is very obstinate, and wants to object officially to sending... What's that? Oh, I see, you will order him to agree with us. Very well, then. Thank you. I was sure you would understand."

B. MIKHAILOV, designer: After talking with Academicians M.V. Keldysh and A.P. Vinogradov, G.N. Babakin was convinced it was scientific necessity to speed up work on bringing back lunar soil to the Earth. He had of course a boundless faith in the possibilities of automatic probes.

His immediate associates found it out in a routine way. They were summoned to a meeting at which the Chief Designer said without preamble:

"We must bring back to the Earth specimens of lunar soil."

Babakin later said that he had been particularly nervous that day. He didn't know whether his principal assistants would support him. If "yes", he would have had no problems persuading the "top" officials. If, however, they did not support him, the station would not materialize.

Yu. SURKOV, D. Sc. (Phys-Math.), winner of Lenin Prize: The news that the investigations of the Moon and planets were also undertaken by another firm discouraged us a little. After all we had been working with Korolev's experimental design bureau. However, as

soon as we found out about the new organization our doubts were dispersed. After a visit to them we understood that the firm was experienced and its researchers proficient.

I had met the heads of several technical organizations, but it was rare to meet people with so much interest in science and who make every possible effort to resolve matters. In this respect Babakin could be singled out. He did his best to understand the problem we wanted to solve and how he could help us.

"We have enough people," he liked to say, "what exactly is required of us?"

This was presumably why Babakin was a favourite of the President of the Academy of Sciences, M.V. Keldysh.

The main task in the study of the Moon was then the analysis of lunar soil. This we have achieved.

Today lunar soil is being carefully examined in many countries of the world. More than half of these countries have received their supplies from the "Luna-16" craft.

A. KOLESOV, Hero of Socialist Labour, winner of Lenin Prize: We have known each other for many years. What often brought us together was our common field of research and in later years space research in particular.

Babakin had a very keen understanding of the tasks and problems of radio communication. I would even go so far as to say that he was a radio expert 'by nature', and used to resolve what we wanted as thoroughly as he could. Others in my place, might have decided that Babakin went deeper into a problem than was necessary. However, I never found him in the way since consideration was one of his main characteristics. It appealed to me that these thoughts were centred round our work, no matter where we were, in a design bureau or at rest, he always wanted the advice and opinion of someone else. I had worked with Korolev for many years; in fact, we were on first name terms and good friends, while I was much more formal with Babakin. However, if I wanted to see Korolev there had to be a reason, while nothing of the kind was required to get in touch with Babakin. A reason for meeting him would emerge during the conversation.

Sometimes, if he came across an unsolved problem he would quite unexpectedly come to my country house on a Sunday. We would then walk in the forest and often

our joint attack on the problem would solve it. We would walk many kilometres together while we were working on the television system for the first Lunokhod (lunar vehicle).

No Stint of Generosity

P. FEDYAKIN: We did not learn immediately how to control the lunar vehicle. We did manage to acquire the necessary skill, but it was chiefly Babakin's achievement. He was always behind us, and what was particularly important, he trusted us. I remember when the lunar vehicle was on the Moon, we ran into a crater. It was quite surprising and unexpected and we found ourselves at a loss. The quest for a solution dragged on. I could hardly deny that the proximity of all our impatient guests standing behind us could be felt. Our room was crowded with them and it was getting more difficult to concentrate on our tasks.

In general, I do appreciate a piece of advice now and then, especially if it is opportune and facilitates my work. This was a special case. Almost everyone could drive and thought he had every right to give advice, which obviously was the only right thing to do. One person said, "move forward," another, "first turn," a third also said something and so on. So much was being said that our heads began to swim and it became quite impossible to concentrate. Besides, it was not opportune to tell them what nuisance they were since their advice was motivated by an earnest desire to help.

Finally Babakin, who had been listening and not saying a word, asked everybody to leave the room. "I mean it," he said to confirm his request. When he saw that someone did not even care to move, possibly believing that Babakin's request did not apply to him personally, Babakin's voice was heard again, "Everybody... including myself. The crew is competent and we have no reason not to rely on them. They will cope with the task, and it is of no great importance whether it will take place an hour later or earlier... After you!" said Babakin gently touching the shoulder of someone still remaining in the room. He let him go out first and firmly closed the door behind him.

Several minutes later Lunokhod continued its journey.

M. KONSTANTINOV, D. Sc. (Eng.), winner of State Prize: The Chief Designer had an unusually keen mind. When he had to choose from a number of designs, he did not hesitate to pick out the one that was optimal and had the most promise. It is difficult to imagine that he could manage to weigh all the 'pros' and 'cons' and to do all the calculations in his head. There must have been something else. Erudition multiplied by intuition, we can hardly tell which of the two was dominant.

He had a very special attitude to theoreticians; it was his belief that they generate ideas, which is what counts. The subsequent realization of an idea is simpler. Though years could be spent on it. I should say that this kind of approach was the reason for the spasmodic development of interplanetary space technology. It seemed that his calendar was ten years ahead.

He could live 'with tomorrow' because of his ability to trust people. He had never penalized anybody and his severest punishment was to be let down. If an idea was suggested to him, it had to be one hundred per cent reliable.

I remember we were working on the "Venera" and suggested another thermal regulation system. Many specialists were against it, but Babakin was confident, and, moreover, told us to think about the landing vehicle, which was to enter the dense layers of the atmosphere.

Now imagine the Centre of long-distance space communication in Evpatoria (the Crimea) and the "Venera-4" millions of kilometres away from Earth. The mysterious planet was approaching. The finishing line was nearing... The vehicle was entering the dense layers of the atmosphere... Everybody congratulated Babakin. This was, of course, a prominent victory. The operator said distinctly: "The descending vehicle is signalling." "Venera-4" was alive! Everybody became active.

The landing vehicle was designed to withstand a pressure of more than ten atmospheres. It stopped signalling when the surrounding pressure reached 18. At that time no one had imagined that the pressure near the surface of Venus could be 100 atmospheres, or that the temperature was about 500 °C! "Venera-4" had unveiled a secret.

Quite a different problem cropped up when Mars was investigated. Conversely, its atmosphere is rarefied (only five thousandths of that on the Earth). How could the descent module be safely decelerated? Would a parachute work? According to our calculations it might, but the last word was still with the Chief Designer. We were in a car together when I told him about my idea of a parachute. At first he argued, then he thought for a while and five minutes later the car was heading fast towards the Institute that dealt with parachutes.

He lived entirely for his work and could not imagine himself away from it. Even his hobby was to some extent connected with engineering. He liked to work on his car, and on Sundays, for instance, he would often be found rummaging in his car, always willing to help others. He had a professional attitude even to his hobby and he could detect fault in the engine by ear.

K. ALTOV, designer: Babakin was an enthusiastic driver. He had handled all the "Moskvich" models, beginning with the antiquated 401.

Although a good driver, he was careful on the street and always moved with the other cars. But sometimes the invisible thread that bound him to those following the 'green light' would tear, he would look sharply forward, his hands would hold the wheel more tightly, and his foot would press down on the accelerator. The distance between his own car and the one ahead would lessen. Nobody could ever tell what kind of car it was and how it could have wounded Babakin's pride. Presumably he could not explain it either, and in cases like these he obstinately pushed himself forward in compliance with some 'inner voice' that made him drive onwards.

By manoeuvring in between the cars, and finding "short cuts", he finally managed to overcome the car he had been chasing. Then with the majestic wave of his hand he saluted the 'vanquished opponent' and calmed down immediately. His car would again make its calm way in the general stream of traffic.

It was only his licence that could tell the true story of its reckless owner.

The fantastic speed with which he used to make decisions, his total absence of fear, and life-long adolescent

fervency manifested themselves in quite unpredictable situations.

N. BABAKIN, Cand. Sc. (Eng.): We first lived in a communal apartment housing 56 people. We only had one room to ourselves. I remember that at the time my father was taking a correspondence course at the Institute. Needless to say, he could only study at night. Sometimes I woke early in the morning to find father sleeping at his desk. Later he worked at night too. It would mean that he could never catch up with his sleep. However, he did succeed in suppressing fatigue. He could doze in absolutely any circumstances, when there seemed to him to be no particular necessity to stay awake. He could drop off in a car, or at a boring conference, opening his eyes at the proper time.

At times it was difficult to understand why he was depriving himself of rest. For instance, he became interested in French, and devoted all his meagre spare time to studying it.

Technology meant a great deal to him, but not everything. He liked animals, and although for many years we had a home aquarium, he secretly craved for dogs and horses. He was a wonderful horse rider (his service in the army helped him in this respect), and always tried to drop in at the race-course whenever he had the opportunity.

Cycling was another favourite pastime. I remember the Sunday two days before he died. We had planned to go for a ride in the forest, but he coughed and I told him to lie down and take some medicine. He objected strongly and said: "A bit of sweat will do me a world of good." That day we covered twenty kilometres.

On the following morning he went to see the doctor, who told him that it was only a cold. Father did not return home, but spent the whole day at work. Next morning, when we were parting for the day, he said: "I am very tired. I think I need a rest today."

When I said "Good-bye" to him, I did not know it was forever. He left the country house and went to his office. On his way there he felt worse and decided to stop at our flat.

He died in his study.

V. LEBEDEV, design engineer: When Georgi Nikolaevich was with us and after he passed away, we often spoke of his incredible ability to work. Only seven years had

passed since the time he took charge of our design bureau, and yet this period was characterized by the first landing on the Moon, the launch of the first Moon satellite, the first landing on Venus, the probe that brought back lunar soil, the first Lunokhod traversing the Moon's surface, the pennon with the Soviet State insignia was carried to Mars and many other things. But how much more could he have done still?

It was August 1971. I had been on holiday with friends canoeing along the rivers in the Arkhangelsk region. Our tour had ended and we were sitting in a small hut at an airfield waiting for the plane. We were talking about our tour and joking. The weather was beautiful. The bright Northern Sun was at its best. Everything around us was green and enjoyed the light and the warmth. A friend was looking through a pile of newspapers, which we had not seen for over a fortnight. Then he said very quietly: "Babakin has died". We were speechless. The news seemed incompatible with our memories of an always active Georgi Nikolaevich speaking about future plans on the day of our departure from Moscow. It was also incongruous with what we saw around us—nature in bloom and the tanned faces of the people full of life. But the printed words, which each of us read with surprise and incredulity, mercilessly informed us that Georgi Nikolaevich Babakin had left us for ever.

Chapter II.8

NEAR GAGARIN

Before the Launch

Extracts from the diary of Colonel-General N. P. KAMANNIN, Hero of the Soviet Union: January 17, 1961. Today the student cosmonauts start their final examinations, and I have been appointed chairman of the commission.

Each student took his place in the cabin of the "Vostok" simulator, and for 40-50 minutes reported on its equipment and his own actions at various stages during the flight.

During the examinations I often asked myself: which of these will be famous and be the first to go into space?

It is difficult to give a straightforward answer, though if all the technical facilities operate properly, any of them could cope with this responsible task. The launch date nears. It will be in either March or April. There is not the slightest doubt that the rocket will take off and enter orbit. However, there are still problems connected with the safety of the landing. Of the three craft launched in 1960 one landed perfectly (the animals were all alive), but one crashed.

Before the live flight it is necessary to launch two satellites with dummies. Let's hope they will have an excellent landing.

Gagarin and Titov are very industrious. Nikolaev is the calmest of the six; Bykovsky is active and full of life. Popovich produces the impression of having enormous willpower.

After examining their personal records, references, medical certificates, and the marks they got during the year, the Commission unanimously decided to award each with an excellent mark and concluded: 'The examinees have all been found fit to undertake the flight in the "Vostok". The Commission recommends the following order of precedence for the flights: Gagarin, Titov, Nikolaev, Bykovsky, Popovich.' This, of course, is tentative and subject to whatever changes that may occur.

February 12. Baikonur. The various space systems are being optimized.

At 3 hours 34 minutes and 25 seconds, exactly the projected time, the Soviet automatic probe left for Venus.

The launch was successful and for about five minutes the rocket could be seen with the naked eye, with the reflected sunlight from its sides clearly visible.

At eight o'clock Moscow time, when it had become obvious that everything was all right, we remembered that we had not had breakfast that morning. In the canteen everybody was in high spirits.

Then Korolev and I went to the hotel, where we had a conversation that I think is worth repeating.

Korolev told me of his plans for the future and let me read his special 'blue' file.

He thinks that heavy satellites and stations with crews from three to five people should be sent into orbit.

Engines with chemical thrust should gradually replace the nuclear rocket ones...

It is difficult to take in the enormous scope of Korolev's plans. We have yet to form a clear-cut idea of what our first cosmonaut can expect in outer space, while Korolev is already thinking of crews.

Once again I spoke with Korolev about the two launches of "Vostok" with the dummies.

We have been informed that the West took the launch of the probe to Venus to be an unsuccessful attempt to send up a manned satellite into space. The Italians even 'heard' groans and interrupted speech, which was certainly no more than imagination. In fact we are perseveringly working on a guaranteed landing of a spaceship with a cosmonaut. It will be interesting to see the world reaction, when Russian will be heard from orbit!

April 10. During morning exercises I played badminton in pair with Gagarin. We won 16:5. Nothing seems to give away the anxiety of the main participants on the eve of the decisive events. Yesterday Gagarin and Titov came to see me. Following my recommendation the State Commission for the "Vostok" launch decided that the first flight should be made by Gagarin with Titov in reserve. Gagarin could not hide his delight, while Titov was disappointed. I told them that soon the Commission would summon them and officially announce its decision.

At eleven o'clock Korolev met the cosmonauts. He said: "Only four years have passed since the first satellite was launched but we are now prepared for the first manned flight into space. Each of the six cosmonauts now present is ready to fly. It has been decided, however, that Gagarin will be the first, with the others following him. This year several "Vostoks" will be prepared, but very soon multi-membered spacecrafts will also be ready. I think that none of the cosmonauts I see before me will refuse to "take us off to orbits" too. We are quite sure that the flight has been prepared very thoroughly and it should be successful. I wish you all the best, Yuri Alexeevich!" I try not to leave Gagarin alone for a minute, and I'm always ready to lend him moral support and cheer him up.

April 11. At five this morning the rocket was taken to

the launch pad. At 10 o'clock Feoktistov gave the cosmonauts the instruction concerning the 'active section of the flight'. This was the 'final touch', so to speak.

At thirteen hours, Gagarin spoke at the meeting. Then he had lunch, which was quite nutritious but was not in the least palatable. I tasted it myself.

For the first course we had mashed sorrel with meat. This was followed by meat paste, with chocolate sauce as dessert.

Yuri feels splendid. At the medical his blood pressure was 115 by 60, his pulse 64, and his temperature 36.8 °C. An hour ago he was covered with sensors to register his physiological functions during the flight. This lasted for an hour and twenty minutes but had no effect upon his general condition. He loves listening to Russian songs and the tape-recorder works practically without a break. Yuri, who is sitting opposite me, says: "The flight is scheduled for tomorrow, and I still can't believe that I am going to fly. I really don't know why I am so calm."

I asked:

"When did you find out that you would be the first to fly?"

He answered:

"I always thought Titov and I had exactly the same chance for the flight, and it was only after you told us of your decision that I could believe my luck."

We decided on the details in Gagarin's schedule for tomorrow. The launch would take place at 9.07 hours Moscow time. Two hours before that he would take his place in the "Vostok" cabin. He will only fly round the Earth for one and a half hours, but two hours before the launch he should be inside the ship waiting for take-off.

It is 21.30 now. Korolev has just visited us to say good-night and go home. Gagarin and Titov are also preparing to turn in. I can hear them talking next door.

What will tomorrow bring?

April 12. I woke at ten to five. At half past five I went to wake the two cosmonauts. They were still asleep. They seemed to be sleeping so peacefully that I could not but stop to watch how serene they looked.

It is time!

At six o'clock the Commission met briefly. All the reports were single phrases such as 'No criticism', 'Every-

thing is ready', 'No questions', or 'The launch can be carried out'. After this meeting I went to the medical. The cosmonauts were putting on their space suits. Everything was strictly according to schedule. At 8 o'clock the spaceship's chief engineer and I went up in the lift to check the code on the digital lock. It functioned quite all right.

There came the last preparations for the flight.

Then I saw the bus with the cosmonauts. Yuri and his stand-by left the bus to find themselves in the warm embraces of many people, each of whom wanted to give Yuri a kiss. It required certain force to tear him away from the crowd. Near the foot of the rocket I shook hands with Yuri and said: "See you near Kuibyshev in a few hours". After that he stepped forward towards the lift.

The first cosmonaut was carried to the crest of a surging wave of glory. After a laborious path in space he had to undertake a strenuous trip here on Earth. The whole world demanded Gagarin. Everybody wanted to know something about his life, his hobbies and whatever he was used to do. It was a role history thrust upon him: to meet thousands of people and represent not only himself, but also the whole of the Soviet Union.

A Journey to India

Delhi. November 29, 1961. At exactly 11.30 local time our "Il-18" plane landed at Palam Airport. Thousands of people had come to greet us.

From the airport we went straight to the residence of Prime Minister Jawaharlal Nehru. After a few minutes of being presented we were on our way to a press conference. We were greeted by about three hundred journalists with photographs popping here and there and blinding floodlights everywhere.

Gagarin was bombarded with questions. People were interested in absolutely everything: what he ate during his flight and how strong the *g*-forces were.

At half past one in the afternoon Nehru gave a luncheon in his residence (the Gagarins and I were accommodated at the premier's residence, which once had belonged to an English Governor-General). Nehru, Indira Gandhi, Krishna Menon, and the ministers were all present. The luncheon was very lively. Nehru is seventy-two, but he

looks older. However, he is very active and continues to devote much time to his work. Indira Gandhi looks tired—she is responsible for all the preparations being made by the Indian National Congress Party for the Parliamentary and Presidential elections.

Two hours later Yuri and his wife Valya were speaking on the radio and television. Gagarin did very well and Valentina Ivanovna, who had no experience of this kind, managed well too.

We went from the studio to the National Stadium. A great fete had been organized in Gagarin's honour. There were athletics, singing, and dancing. It is above 20 °C in Delhi today and bright sun in the blue sky together with the green carpet of the stadium dappled with the colourful national sporting uniforms, to say nothing of the remarkable performance itself, produced a wonderful impression. The city's mayor made a speech and presented us with gifts. Gagarin had to say something quite extemporaneously.

Then for several hours there were visits to the Vice-President, the Chief Marshal of Aviation, and so on.

Six of us had dinner: Nehru, Indira Gandhi, the Gagarins, a representative of the Ministry of Foreign Affairs of India, and myself.

Nehru hardly said anything. He seemed to be drained, but when we started speaking about the invasions of India, he brightened up, and mentioning Genghis Khan, said that India had known seven empires and seven different dynasties. Indira Gandhi kept the conversation going perfectly. Her enormous political experience was clearly felt by everyone. Disregarding our protests, Nehru and his daughter personally saw us to the rooms that had been specially prepared for us.

Every new exploit Gagarin has to tackle convinces us that we made the correct choice. It is hard to credit the fact that a little more than six months ago the world knew nothing of the twenty-seven-year old youth, contact with whom is now regarded as an honour for prime-ministers from many countries. However, Yuri can now hardly be called a youth. He has become mature and remarkably concentrated. Sometimes at press-conferences I find myself completely at a loss as to how to escape a verbal 'trap' set for Gagarin by the journalists, whereas he

merely smiles and circumvents all the 'reefs' as though he were a trained diplomat.

Half a year can really be a good experience to anybody.

A knock at the door woke me up at half past seven. Last night I fell asleep at once, and when I heard the knock this morning, I didn't quite realize that I was not in Moscow, but in fabulous India. I don't remember ever to have been quite so sound asleep.

We breakfasted on the lawn in front of the palace. Gagarin then met with President's boyscouts. Nehru and several of his ministers were also present.

At ten o'clock we lay a wreath on Gandhi's grave and left for Safdarjung Airport, where the glider club is situated. The Minister of Aviation, the Club members and their families gave Gagarin a warm welcome. The sportsmen gave us a demonstration of their gliders.

After that we visited India's President Prasad, who was confined to his home because of illness.

The formal greetings over, he said: "I have been here (the former Viceroy's Palace) for twelve years, and it's the first time that I have fallen ill. It's my legs, but things are getting better of late." We wished the President a speedy recovery and gave him the book *The Dawn of Space Era* as a little gift.

The warmth with which Gagarin spoke moved the President.

One meeting followed another.

Our general impression of the two days we were in India is favourable. Nehru and the country's administration have given us a very warm and hospitable reception. The Prime Minister, who as I have already mentioned is very busy, allotted us a great deal of time. His working day begins early in the morning and ends late at night. His activities are tremendously wide ranging (he even flies gliders).

The two days in Delhi were heavily booked (from nine in the morning till eleven at night). Our itinerary has been well thought of, but we are really tired.

The newspapers, radio and television have reported on Gagarin's visit very cordially.

Yuri has been doing quite a lot to nurture mutual understanding between the peoples of India and the Soviet Union.

On the following morning we flew to Lucknow, the State capital. The city's inhabitants showed their profound respect for Gagarin and his country. All the streets were filled with people. Most of the members of the Municipal Council, in defiance of some who did not agree with them, decided to organize the best possible welcome for Yuri.

The day Gagarin was to stay in Lucknow was officially declared a holiday: all the schools, colleges, the university and offices were closed. Children and adults all came to greet the Soviet cosmonaut.

Bombay. Immediately after our arrival several press conferences, receptions and meetings were held. At ten in the evening we drive to the famous film studio. All along our way, about twenty kilometres, stood thousands of people on each side of the road.

The studio management spared no effort to greet Gagarin very impressively. A wide carpet covered the two hundred metres of the road to the main pavilion and all trees were decorated with coloured lamps. Music, strobtop and dancing were everywhere.

India's film-stars were there too. We found ourselves amidst many beautiful young women. We also met Raj Kapoor, who impressed us and saw us to our car when we left.

Early in the morning before it was the official time to wake, Yuri and I went to swim in the Indian Ocean. It was the only opportunity we had to free ourselves from people and the constant feeling that everyone is looking at you.

Then came the meetings again.

More than three hundred thousand people gathered in Shivaji Park, while on our way to the Park the road was lined by half a million people. Moreover, many of those who saw our motorcade did not leave and waited to see us return. The Chief Minister said that more people came to greet Yuri Gagarin than had awaited the Queen of England herself.

Almost all the papers say that Gagarin's trip showed 'how great the Russians are'. However after seeing this great man every day as I do in the centre of all that prodigious splendour, I can understand his desire to get

away from people and sit on the bank of some little river near Moscow fishing.

I also remember a conversation Gagarin had with a five-year old Indian boy, who gave a very thorough account of how long and how high Titov's and Gagarin's flights had been, and even knew that the American astronaut Shepard came back to Earth right after his take-off. But when Yuri asked him how old he was, the boy replied: "I'm five, and I shall soon be seven."

Isn't it one of the epoch's paradoxes: the boy knew more about the outer space than about his own age.

Calcutta. At the Great Eastern Hotel we met the members of the International Aviation Club.

Gagarin was presented with a silver globe with a satellite. I received a gift of a two-wheeled cart pulled by two ivory bullocks. During the meeting I was asked: "Help India to get into space."

Yuri said: "India shall certainly get into space."

Hindustan flows past under the wings of our plane. We are heading for Ceylon. Yuri is sad and I asked him how he liked it all.

"The country is very beautiful indeed, and I tried to make my visit pleasant for them. I'm sorry that I couldn't do much for myself. I haven't even seen any elephants."

Gagarin seemed to be controlled by the events rather than the other way round. The numerous trips, meetings, speeches, and conferences often felt like gala performances. However, this did not prevent him from improving his skill, which was the most important thing for him in life. He worked to train cosmonauts and developed new programmes. Even more, he cherished a dream of flying to the stars and returning to aviation. He waited for his return to a solo flight in exactly the same way as he had once expected his historic launch. The flight was scheduled for 27 March 1968. But let us go back to the reminiscences of Nikolai Petrovich Kamanin.

Back to the Sky

It was a very busy morning, and I was in a hurry to get to the airport to congratulate Gagarin on his solo flight.

At 10.50 a message came.

"The Uti-MiG-15 with Gagarin and Seregin took off at

10.19. After thirteen minutes communication with the plane ceased.' This was unpleasant news, but knowing the conditions of the flight as well as the proficiency of the two, I still hoped that an ace pilot such as Seregin would find a way out of the situation and that he had either made a forced landing or they had ejected.

After reporting the incident, I ordered a search and immediately left for the airfield.

At the control centre they were expecting me. The report was very brief: 'Two Il-14 planes and four Mi-4 helicopters are in the air. They are searching in the area of Kirzhach, Pokrov, and the eastern part of Moscow region. The weather and the visibility of the earth are good, but so far no trace of the Uti-MiG-15 has been found'. Having narrowed the search area, we divided it into several 10 by 10 kilometre squares, and searched each uninterruptedly with the helicopters flying at 80-100 metres, the Il-14 plane going up to as high as 300-600 metres. Thus the whole of the district where the accident might have taken place would be examined.

According to the specified data the situation connected with the flight of Gagarin and Seregin was the following: they were to do no more than a solo flight in a particular zone. The flight height was 4000 metres. The weather was good with double-layered clouds, and the visibility under the clouds and between them was more than 10 kilometres.

After take-off, Gagarin asked the control centre for the permission to take over. After accomplishing the task, he was allowed to turn and head for the airfield. Then at 10 hours 30 minutes and 10 seconds all communication with the plane ended, and calls from the control centre were unanswered. The radar kept track of the plane until 10.43.

Rescue planes and helicopters immediately took off in search of Uti-MiG-15.

All attempts to find the plane remained fruitless for quite some time. At 14.50 a helicopter commander reported: "I can see plane wreckage three kilometres from the village of Novoselovo." I instantly flew by helicopter to the accident site.

The deep snow in the fields and forest still remained pristine with only a few small thaw patches appearing in

places. It was extremely difficult to look for white parachutes (on my way there I had still hoped that the crew had managed to eject). After several minutes we were in the district of Novoselovo. Two helicopters had already landed two kilometres from the village.

Another helicopter was in the air besides ours. It was circling above the forest to show us where the Uti-MiG-15 had crashed. I have some considerable experience in spotting aeroplane wreckage from the air, and my sight had never failed me, but on this occasion I could only discern traces of the catastrophe after circling for the third time. We landed at the edge of the forest about eight hundred metres from where the plane had fallen. The snow was more than a metre deep, and with each step our feet sank to the ground. It was very difficult to walk. It took us an hour to get to the crash.

The plane had fallen in thick forest and it had been travelling at about 800 km/h when it hit the ground. The impact broke the plane into tiny fragments. The engine and the front cabin went more than 5 metres deep into the earth. The wings and tail unit, tanks and cabins broke into parts and were scattered throughout an area some 200 metres in diameter. Parts of the plane and parachutes were found high in the branches of the trees.

Soon it became clear that one of the crew had perished. The doctors reported that it was V. S. Seregin. There was no trace of Gagarin and yet there was little hope he had saved himself. At 16.32 we found the pilot's chart board. There was some reason to think that it was Gagarin's but one could not be sure because it could have been left in the cabin before they ejected, and besides whether it really belonged to Yuri was still debatable.

It was getting dark and the search could not be conducted at night.

The emergency commission met at the aerodrome's command centre till nearly three o'clock in the morning. They looked through all the documents on the regulation and planning of flights, questioned dozens of experts including pilots, unit commanders, engineers, flight control officers, and operators. After prolonged analysis of the material and the evidence of the witnesses, all the commission members were sure that Gagarin had been in the air-crash, although irrefutable proof of his death

was absent. It was decided to continue the search with planes at night and with planes, helicopters and skiers at dawn (there was still some hope that Gagarin had been ejected).

It was then decided to have a short break. I remained awake the whole one and a half hours. As in a film, I remembered meetings with Gagarin. There were thousands of them and Yuri had always been active, cheerful, full of life and energy. It was hardly possible to imagine that Gagarin would no more be with us. Gagarin was life itself and the ungovernable dream of the sky, the flights and space.

At 5.15 a.m. the whole commission gathered at the airport, and quarter of an hour later we all flew to the crash site.

We could not find anything to throw light on our quest until seven in the morning. However, we did establish that the chart board we found the previous day belonged to Gagarin (it contained notes written in red ink and A. S. Nikolaev confirmed that he saw Yuri write something in the flight log-book in red ink, this book was fastened to the pilot's knee with a belt). At about 8 a.m. I saw a piece of some cloth that turned out to be part of Gagarin's jacket. In the breast pocket of his jacket I saw a breakfast coupon issued to Yuri Alexeevich Gagarin. There could no longer be any doubts, Gagarin had died. I left the accident site in a helicopter to inform the government of the sad news.

Valentina Tereshkova and Gagarin's relatives went to the hospital to see Valentina Ivanovna (Gagarin's wife), where she had been staying for over a month. They came to tell her of the death of her husband—the woe that befell us all.

Popovich, Bykovsky, Belyaev and I went to see Colonel Seregin's wife on the same mournful mission.

The funeral left me with a misty recollection.

I was asked to speak on the television. I was supposed to answer the question everyone raised, 'Was it necessary for Gagarin to fly? Did he have to do it?' My answer was: 'Gagarin could not stay away from flying. It was his life. Asking whether a cosmonaut should fly is unnatural. It would equally be strange to ask if a swimmer should swim, a seaman should go to sea, or a man should walk.'

Not every pilot can be a cosmonaut, but no cosmonaut can do without flying'.

The emergency commission worked day and night and news came that the plane's engine, most of the front cabin, and many parts had been recovered. It had also been established that at the time of the crash the plane was intact (fuselage, engine, wings, tail unit, suspended tanks, and the control system), after which it broke into small pieces. Gagarin's wallet containing his driving licence, seventy four roubles, and a war-time photo of Sergei Pavlovich Korolev taken at the front were also found.

Thousands of Moscovites came to part with the deceased.

It was thought that the access to the Urns would be ceased by 9 o'clock in the evening, but the stream of people continued well into the night.

The cosmonauts and I went to the Gagarin flat. Valentina Ivanovna met us in Yuri Alexeevich's study: everything here had been left as it was on the morning of March 27, when its master left, never to return. We told Valentina Ivanovna of our plans to immortalize Yuri Alexeevich's memory. Valya listened very attentively, she did not shed a tear, neither did she say a word. Only her slight nod gave us to understand that she supported our proposals.

I said: "Valya, You know better than anyone else how I felt about Yuri. I treated him as if he were my own son, and we have all been shocked by what has befallen us. The grief that we have lost our best friend and comrade shall remain with us forever. We fully understand how irrevocable your loss is, and it is quite useless to try and comfort you; we shall not make any effort to do so, but we do ask you to take care of your own health and Yuri's children. You must live for the sake of Yuri Alexeevich's memory and in order that Gagarin's daughters should be worthy of their father."

Leonov, Titov, and the other cosmonauts also spoke well. We gave Valentina Ivanovna our word that the memory of Yuri Alexeevich would remain sacred to us.

On March 9, 1984, Yuri Alexeevich would have been fifty. In our memory he will always remain young, full of life, and as active as when the world first heard of him early in the morning of 12 April 1961. His name has been

given to cities, avenues and squares, academy and pioneer groups, enterprises and ships. New space expeditions from the Yu. A. Gagarin Centre, where cosmonauts are trained, continue to go into space and thus perpetuate what was initiated by Gagarin. However, it is not less important that his remarkable life serves us as a pattern on which to model our thoughts and deeds. It is not surprising that generations of Soviet people say, and will always say with pride: 'Our Gagarin...'

Part III

Nothing Whimsical

Chapter III.1

CONFRONTING SPACE

Academician O. GAZENKO: The flight of man into space, space walks, human steps upon the Moon, and work in orbital stations are the things that anyone would have hardly predicted a quarter of a century ago.

If we tried to decide what has been the main achievement of cosmonautics since then it would be that man has secured a firm position in space flights, while human beings have become crucial in the strategy and tactics for developing and studying outer space.

What then has been the progress in space medicine and biology?

Firstly, more light has been thrown on the effects of space flight on humans, animals, and plants. Secondly, ways of combatting the ill effects have been sought. For instance, today we know something about the reactions to weightlessness and understand the basic principles governing them. On the whole, it would appear that human beings can adapt to prolonged weightlessness. We have also been able to make the conditions in a spaceship more conducive to human and animal life.

However, it should not be thought that space medicine has no terrestrial application. Many of the instruments and techniques developed to train cosmonauts and to be used in orbit have been successfully employed on the planet too. Space experiments have also influenced theories on the origins and evolution of life on Earth.

Soviet scientists are cooperating on research with colleagues from Bulgaria, Hungary, the GDR, Poland, Romania, Czechoslovakia, the USA, France and a number of other countries. Joint experiments are under way both here on Earth and in the "Salyut" stations and the "Kosmos" biological satellites.

The main activity remains wide ranging investigations of the mechanisms underlying human vestibular disor-

ders, and due to changes in the water and electrolyte balance and the losses of calcium salts, which are important constituents of bones.

Radiation safety for the crew, which has up to now not been important, will soon be critical. Present missions take place below the Van Allen belts and so radiation is not obvious danger. However, as we start to see interplanetary missions, radical changes will be inevitable. It will then be necessary to take into serious consideration the biological activity of cosmic radiation, especially influence on the brain. Since this kind of ionizing radiation cannot be simulated on Earth the requisite biological experiments will have to be done in space.

Future flights will require autonomous ecological systems aboard a ship that would be able to exist for a relatively long time and relatively stably with their own mechanisms of regulation and control on the basis of enclosed biological rotation as happens in the Earth's biosphere.

The problem of gravitation is also relevant. So far no satisfactory general theory has been devised explaining the influence of gravity on living beings. Biological experiments in space enable us to see what effect it has on biological processes such as cell division, the hereditary transmission of information, and growth and development.

The number of problems is clearly very great. Nevertheless, progress to date is equally impressive. Future space studies, which often seem to be no more than imagination, are still greater in magnitude.

Tens of thousands of designers, engineers, workers, and the testers are to be found at the forefront where the Universe is being discovered. It is not always possible to name them all. But this does not depreciate the cause they serve.

In what follows an immediate participant in the preparation of space missions tells us about his work.

In a Weightless World

My favourite day-dream was once that I should experience weightlessness—to be light, free and soar in the air. I remember how weightlessness began for me.

I went up to the highest floor of a large circular building and on entering the laboratory, found myself immediately in hands of the scientists. The last instructions were given to me and the last measurements taken. Everything was normal. I marched into the next room, a large hall at whose centre there was a life-size model of a space station. The floor seems to be unstable, or to be more exact, it looked like a colander with water glistening through the holes.

The station gradually submerged into a huge pool. My own turn came several seconds later.

The most difficult part of the procedure then began. I got into the spacesuit, which was suspended below a valve. It was like being in the armour of a mediaeval knight. The helmet clicked on my neck and then I could only communicate with the outside world by radio. I was 'suspended' and my hands and feet could not move because lead had been sewen into the spacesuit.

I saw Pavel Popovich waving good-bye at me. The valve took me below the water surface, the cable was unhooked and I was smoothly pulled deep down to where the station was now standing. The weight of the spacesuit and myself were equal to the weight of the displaced water. Consequently, according to Archimedes' law I was in equilibrium and weightless.

It is a very peculiar sensation. I could feel the spacesuit and could move without hindrance, but my movements were incredibly awkward. I had to make an effort to swim to the station. My task was rather simple: all I had to do was 'swim' into the station and simulate an exit into space from the air lock. At last I got to the starting-point.

Then it was time to leave the station. My first attempt was a failure and I kept finding myself out of position with respect to the open hatch. I tried again and again.

Finally I succeeded in getting out. One clumsy movement and I turned round and round. I was swimming with my feet above my head and had no idea of top or bottom.

The training over, the pulley 'pulled' me out of the water and I got out of the spacesuit. I was very tired and my legs did not want to obey me. That was what weightlessness is really like!

Adding up all the time I have spent under water, it would come to much more than a day. It was only then that I realized the meaning of the axiom: 'In weightlessness you do everything very slowly.'

You may find training in a pool rather strange. However, it has sense. If someone cannot be taught to live and operate without 'top or bottom', he would not be able to accomplish anything in orbit. It is very difficult to create weightlessness for training on Earth. There are only two ways: either for a short time (several tenths of a second) in a plane as it falls or by using the 'weightlessness' of a swimming pool. The water alternative has many advantages which is why the unusual building appeared in the Centre for cosmonaut training in Star City.

Unfortunately, the loss of space orientation is not the worst evil of weightlessness. In a weightless world, and, consequently, without the usual loading on the body it begins to dehydrate and there is a loss of muscle mass, the cosmonaut begins to lose weight.

I remember the first time I saw the "Salyut" station, the exercise area did not particularly impress me. I could not understand what was so extraordinary about the 'running track' and various expanders. Only later did I realize that it was this sport complex that enabled the cosmonauts to stay in orbit for as long as two hundred days.

The mission of Andrian Nikolayev and Vitali Sevastyanov aboard "Soyuz-9" spaceship only lasted for 18 days which is not long by present standards, but sixteen years ago it was a significant achievement. The cosmonauts experienced enormous difficulties. Weightlessness affected them severely: there was no 'stadium' aboard the spaceship, nor did the cosmonauts have clothing to help overcome the unusual conditions. Nowadays, cosmonauts wear 'Penguin' suits when in space. It is made of cloth into which rubber is woven. Effort has to be exerted to produce any movement in it, therefore, like it or not, the cosmonaut's muscles always undergo a certain stress.

After Nikolayev-Sevastyanov mission many experts were downcast at the thought that any mission in space would involve so much tension. Then came new training techniques and new experiments. The next crew went

into space and reported from orbit that they could last there another month or so. It was a victory for the doctors, designers, and, of course, the cosmonauts themselves.

I have administered many communication sessions between the Earth and space here at the Centre for medical observation, which is situated at the Institute of Medical and Biological Problems of the USSR Ministry for Health. The medical and biological state of the crew is sent here straight from orbit. All changes in the cardiovascular or locomotor system are duly registered.

During the 140-day mission of Vladimir Kovalenok and Alexandr Ivanchenkov, a most important parameter was the erythrocyte, or red blood cell, count. Erythrocytes only have a life span of 120 days and on Earth they are continuously being destroyed and new ones are regenerated. Thus, every 120 days their content in a person's blood is entirely replaced. Unfortunately, the same cannot be said of space. Preliminary research indicated that the blood cells were not being as quickly replaced in space. Hence it was possible that by the end of the 120-day period cosmonauts' erythrocyte count would drop to a dangerously low level.

In those days the Centre looked like a medical laboratory. The dynamic electrocardiographs of the cosmonauts were being taken and their hearts' electrical activity was being recorded continuously round the clock.

The cosmonauts took regular blood samples which were sent to Earth on the transport craft. They only showed a moderate decrease in the erythrocyte count and haemoglobin level. This meant that by making use of all the facilities the cosmonauts were retaining a fairly high volume of circulating blood.

Each flight generates new information on effects of weightlessness and new mysteries. For instance, does the decalcification (loss of calcium) of bones stop during a space flight and if not is there any way of combatting the phenomenon?

If 'enemy number one' is weightlessness, the next important problem is the psychological aspect of space flight. A cosmonaut has to be both a researcher and a research subject. However, let us begin at the beginning.

When a person passes through all the stages for selection as a cosmonaut, it is quite natural that efforts are

made to assess the candidate's psychology. The doctors not only carry out exhaustive analyses, they also carefully observe the candidates. For instance, I thought that the long talks I had with Mikhail Novikov, the head of the laboratory for medical and biological problems, was spontaneous communication between two people. We didn't even talk about cosmonautics, and discussed other, quite different things. Later, he admitted that he had been analyzing me. After all, it was when many of my friends were being rejected, and they were packing to go home. It is difficult to say what my own fate would have been had I betrayed traces of pessimism or apathy.

Life gives us surprises of quite a different kind too.

Yuri GLAZKOV: It happened when the "Salyut" station was flying over Brazil.

I have great pleasure examining the surface of our planet through the cabin-window, and it did not take me much time to identify the rivers, lakes and mountain ranges. I could tell you with my eyes closed what the landscape over which the station would be 'drifting' would look like.

Thus, while we were over Brazil, I suddenly saw a thin ribbon and instantaneously recognized it as a highway. A real bus was moving along it at great speed. Reason told me that it would be impossible to see it with the naked eye at such a distance. However, I did see it!

After the flight he told his story to Andrei Aksyonov, a geographer, who suggested that the sensation had been due to association. In other words, no sooner had the cosmonaut imagined a bus, his eyes saw one in reality.

This explanation has been confirmed by some of well-known 'terrestrial' observations. (Incidentally, one version of the 'Flying Dutchmen' legend is based on them.) However, there are other explanations. The wish to see something 'native' (with Glazkov it was the bus) has been experienced by every single cosmonaut. But no one except Glazkov ever saw anything like this. Future investigations are bound to throw more light on the phenomenon.

Some might ask why the selection must be so rigid? The extreme conditions of spaceflight demand that the cosmonaut must cope with all the psychological tests. However, the selection is only the beginning. Candidates

for the launch are given special psychological training. Firstly, it is impossible to teach anyone beforehand how to behave in any extraordinary situation in orbit. The only thing that can be achieved is to train the person's will and self-control so that he will have a 'clear mental perception' and flexible intellect to avert impending distress. This will help him to make the required decision. Secondly, during prolonged missions pilots may experience sensory deprivation, i.e., the absence of external stimuli he or she is accustomed to. Hence, the problem of psychological compatibility of a crew becomes more important.

The 'survival' experiment is aimed at training will-power and making decisions under extreme conditions. In my case I had to walk from Alma-Ata to Lake Issyk-Kul in only a few days. At first glance the task is not difficult, 75 kilometres could hardly be called insurmountable. However, my route was not along the highway, but straight across the mountains. We had found our way by the stars, and yet we arrived on schedule. To tell the truth, I did lose weight, but the six days were not wasted.

To find out more about sensory deprivation I worked for two months on a special simulator. The distinctive feature was that the tests took place in a closed pressurized cabin. There is no contact with the outside world and the subject is placed in social isolation. On some days I lost all interest in work, and had no wish to do anything at all. It took great efforts to overcome my apathy.

I was once ordered to stay awake for three days running.

The first day went by rather easily. On the second day the desire to lie down grew steadily and I tried to engage in every kind of activity possible, but my hands and legs seemed to be made of lead. By the end of the day I was afraid to sit on a chair lest I should fall asleep. We were becoming steadily more indifferent. On the third day I suffered headaches and the doctors recorded increased blood pressure and pulse rates.

The path to space is not strewn with roses.

The work of psychologists is very important. Much depends on how well they can assess a particular individual. Would they be able to assist a pilot in space, knowing all his weak points?

Some words should be said about psychological compatibility.

This is what Alexei GUBAREV, pilot-cosmonaut of the USSR and twice Hero of the Soviet Union, told me about his flight with Georgi Grechko aboard the "Salyut-4" station: It was 1975 and as usual at the first stage in our flight our health deteriorated with nervous tension rising and certain elements of discomfort becoming more evident.

Thus, for the first three days in orbit Georgi and I were on the same friendly terms as we were back on Earth. Our relations were professional, mutually respectful, and normal under the circumstances.

Several days later we started feeling our nerves more acutely. Sometimes this would express itself in us evaluating the same event in different ways.

I soon discovered that Georgi was losing his self-control; he was becoming rude and nervous. Back on Earth his characteristic features were self-control, modesty and calmness.

Interestingly, when we were in the simulator on Earth, we had never behaved in this way.

Both of us tried to suppress our tensions, we had to iron out our differences, forgive each other, and reconcile ourselves to deviations in the activity and conduct of each other.

We have managed to succeed quite well.

The example shows the role played by the psychological training of crews.

I have dwelt on the difficulties of long-term missions simply because the future belongs to them, and because expeditions even to Venus (the Earth's closest neighbour) will require a mission of several years. As for orbital missions around our own planet, the longer the mission the more important it will be.

Prolonging the time cosmonauts remain away from Earth brings another problem, that of life support. To lengthen missions in orbital stations water, food, and air is supplied to the "Progress" craft, which are sent regularly into orbit. However, if a spaceship is launched to Mars, how can the resources be replenished? Scientists have been trying to solve this problem for many years, and there has been some progress, including an experiment I took part in myself.

The room I was to live in for a month was very simple. It contained a rocking-chair and a small table. However, hardly anything else can be said about it except that it was only five cubic metres in volume. It had all the characteristics of a sealed pressurized cage. I could do no more in it than stand, lie and sit. Walking was not possible, but what troubled me most was the thought that my month's supply of air was the volume in which I was to live, i.e. five cubic metres. If air is not renewed, a person cannot survive for more than a day.

In my experiment the carbon dioxide was to be transformed into oxygen by green microalgae, or chlorella. A reactor through which the atmosphere would be passed contained 30 litres of the suspension of this simple plant.

The door closed and through a small window I saw how Ganna Meleshko, a doctor of biological sciences, and Yevgeni Shepelev, a doctor of medicine' did their witchcraft' with the instruments outside.

I have not yet mentioned that my food ration included bread made from chlorella. Thus, the experiment was to look at the possibility of creating a small enclosed ecological system, which received neither oxygen, nor water from outside. The chlorella reproduced and I ate part of the crop. The carbon dioxide I breathed out was absorbed by the chlorella, which on its part released oxygen. And thus the reproduction went on...

The month dragged by rather slowly, but there was no discomfort. When I left the chamber, the medical people examined it and considered the atmosphere to be quite fresh. The air was very much the same as that on the Crimean sea-shore.

The next experiment was conducted by Meleshko and Shepelev, and involved higher plants such as wheat, carrot, beet-root and lettuce. The overall crop area measured 13 m².

Simultaneously the scientists studied how the conditions in space influenced the plants. Chlorella could stand weightlessness perfectly well. Anatoli Berezovoi and Valentin Lebedev's mission revealed that higher order plants grew well in orbit. A little plant *arahidopsis* not only sprouted, it also yielded seeds that germinated on Earth.

Another aspect in the research programme was the

inclusion of animals in an enclosed ecological system. The Japanese quail was chosen, primarily because its meat is rich in calories and its eggs may also be eaten. The first experiment was conducted by Soviet scientists in collaboration with Czechoslovakian colleagues.

Yevgeni Shepelev is full of optimism. He believes that very soon there would be an opportunity to substantially reduce the dependence of crews on supplies from Earth and this is undoubtedly an important step to missions to Mars, Venus and Jupiter.

Of course, this is only the beginning. The problems confronting scientists studying the topic 'Man and Universe' are gigantic in scale.

The more I work, the clearer it becomes to me that space is a road without end.

'Living' Satellites

E. A. ILYIN, researcher at the Institute for Medical-and-Biological Problems, USSR Ministry of Health: Several biological satellites have been sent into orbit over the last few decades. In 1966 two dogs, Veterok and Ugolyok ('breeze' and 'little piece of coal') set a record of twenty two days in weightlessness aboard the "Kosmos 110".

The honour of working in orbit does not entirely belong to dogs. Substantial contributions to the research were made using white rats - animals which have been used by biologists and physiologists for a long time on Earth. They were as helpful in space.

The rat investigations required a whole series of difficult problems connected with the life support of these space travellers to be resolved. Living compartments were built, to which food and water could be delivered by command, waste removed, and the rhythm of day and night regulated.

A very interesting experiment was carried out in 1977. A group of rats on board the "Kosmos-936" satellite was placed in a centrifuge which created artificial gravity equal to that on Earth. The experiment showed that many of the unfavourable changes that emerge under weightlessness can be averted by the technique.

A serious problem which has been studied is the long-term consequence of space flights. A small group of rats

that had been in space was kept in their usual laboratory conditions until they met natural deaths. Their life spans proved to be as long as those of rats in the control group which had not been in space. The descendants of the rats that had been in space did not differ in any way from those in the control group.

These investigations have considerably increased our knowledge of the factors underlying the adaptation of animals to weightlessness.

Preparations are now under way on the next experiment, while just recently a chimpanzee, mammal closely related to human beings, completed a space mission.

Lunch in Orbit

A.S. USHAKOV, D.Sc. (Med.), winner of the USSR State Prize: The energy consumption of a cosmonaut is a little over 3000 kilocalories per day. Therefore, their food ration should match their calorific expenditure.

The menus for the crews of the "Salyut" orbital stations are varied with requests by members of the expedition being taken into account. The menus include different dishes in tubes, in dehydrated packets, tinned meat and fish, garnishes, all kinds of bread and confectionery. The following is the menu for one day:

Early breakfast: smoked pork, mashed potatoes, wheat-en buns, sticks of quince, and coffee and sugar. The second breakfast: cheese, biscuits, and apple juice with pulp. Lunch: jellied sturgeon, sorrel soup, 'home-cooked' beef, rye-bread, grape-and-plum juice, and prunes. Supper: chopped pork with an egg, cream cheese with nuts, rye-bread with caraway, sweets, and tea and sugar. In addition, the "Progress" transport vehicles bring cosmonauts fresh fruit and vegetables, and other products as requested by the customers.

'Guests' also took with them into orbit the so-called guest sets, including national dishes.

The "Salyut-7" Soviet-French crew was not an exception. The cosmonauts were served pâté à la paysanne, cream made from crab meat, and other national dishes.

It goes without saying that in choosing a particular food ration for the cosmonauts the physiological changes in the bodies of the cosmonauts due to prolonged weight-

lessness must be allowed for. For instance, the absence of the usual loading finds its expression in increased calcium losses from the body. Hence, cosmonauts have the food fortified by minerals, particularly calcium and phosphorus. To help cosmonauts cope better with the last stages of a long flight and the onset of Earth's gravity, and then to reacclimatize to terrestrial life, in the last days of the mission they take a complex of vitamins, amino acids and minerals, which help the organism with the difficult consequences.

Verified by the North

N.N. GUROVSKY, D.Sc. (Med.), winner of the USSR State Prize: There are many examples of how the achievements of space medicine have been applied on Earth. Clinical medicine now employs a whole range of physiological and psychological tests, many of which were developed to help select and train cosmonauts. They involve investigations of the cardiovascular system, water and salt metabolism, and the vestibule.

To investigate changes in the oxygen supply to human tissues during space flights Soviet and Czechoslovakian scientists have devised an apparatus known as 'oximeter'. It is now widely used for diagnosis in the clinic on patients with gastric ulcers or cardiac ischaemia. The method also makes it possible to assess a surgical intervention into the brain vessels.

A technique to ensure the living conditions of cosmonauts during missions included personal hygiene procedures, food, and first-aid kits, and was also used by the members of the 'Komsomolskaya Pravda' (the name of the central newspaper for the youth) polar expedition, participants on Thor Heyerdahl's 'Ra' and 'Tigris' expeditions, and Soviet mountain climbers during their ascent of Everest.

Exhaustive and systematic examinations of healthy people, cosmonauts, at different times: during selection and training, space flight, and again during training have helped us understand the normal physiology of man. The ability to cope cosmonauts have shown with such an unusual condition for the human organism as weightlessness, and then their reacclimatization back to Earth's gravity reveals that human beings possess a far greater scope of

adaptative power and inner potentials than had been assumed before. Space medicine has accumulated vast experience on the active control of adaptation and the stabilization of human health in extreme conditions, which is undoubtedly a major factor for the theory and practice of medicine.

Chapter III.2

FACTORIES BEYOND THE EARTH

O.G. IVANOVSKY, chief constructor of the "Vostok" spaceship, winner of Lenin and State Prizes of the USSR: The late twentieth century is beyond any doubt an 'hour of triumph' for humankind. Having overcome the terrestrial gravity scores of spaceships have made their way into outer space. Places such as Baikonur and Star City have become synonymous with the new epoch. However, Baikonur has a 'cosmic past'. In 1848 the news bulletin for Moscow Province published the following item: 'It is hereby brought to the notice of the inhabitants of Moscow and the provinces that Nikita Petrov, a resident of the Zamoskvoretsky district, has been found guilty of organizing illegal gatherings and making trouble-making speeches about journeys of people to the Moon. He has been exiled from Moscow under police surveillance to Baikonur'.

If in the nineteenth century the ideas concerning space flights were entirely the domain of scientific-fiction writers, today they are a subject for common discussion. Strangely the number of people opposing space flights is growing from year to year. To see why, let us turn to the facts.

One minute in space which the first American astronaut John Glenn spent (the mission took place in 1962 and lasted five hours) cost 1,680,000 dollars. Even though subsequent launches have become 'cheaper', the costs are still very large.

The second argument of these opponents arises from the insecurity of space flights.

Lastly, they ask why man needs space at all. Don't more urgent global problems exist on Earth? True we must struggle for the development of controllable nuc-

lear fusion, the protection of the environment, the eradication of cancer, and so on.

Even so I do believe that space flights are profitable. In the first place, the money spent on them pays for itself and, moreover, augments the gains. Nowadays we need no longer speak so much of investigating, but of utilizing outer space. Space satellites help meteorologists, geologists, cartographers, seamen and dozens of other professions. We now can not only evaluate agricultural land and its fertility, but also influence the productivity of meat and wool (flocks of sheep are now moved according to recommendations from orbit).

Secondly, many terrestrial problems, such as the energy shortage, may be solved by utilizing space. Scientists are suggesting that a satellite in a geostationary orbit transform solar energy into electricity, which can be transmitted to the ground stations as microwave beams. A single orbital power-station will have a capacity from 5000 to 10 000 megawatts.

This is realistic today, but what will tomorrow bring?

One Hundred Space Professions

The Geologist

The plane covered the several hundred metres of runway and took off into the sky. It was a very special flight. On board the Tu-134 there was no one other than the crew and the few members of a special group. We were to travel quite a distance and so we had time to talk a great deal. *Vladimir KOZLOV* (his profession will be mentioned later) *began speaking of the future*: The earth's crust continues to change. Vast forces reform the world we are familiar with. There are serious reasons to believe that the coming decades will be marked by earthquakes and volcanic eruptions which will bring on great disasters and tragedies.

Further, Kozlov explained that most geologists adhere to the theory of 'tectonic plates', according to which the earth's crust consists of large plates floating upon the mantle and moving slowly. These gigantic platforms hold the continents and where the plates meet we have earthquakes and the eruptions of volcanoes. Using sensitive

instruments scientists are collecting larger amounts of data about the future catastrophies in the regions the plates meet, or 'faults'. For instance, some forecasts indicate that a very strong earthquake is expected in southern California within the next 30 years. It should register 8 or more degrees of intensity on the Richter scale, and in Los Angeles there may be 23 000 human casualties and a damage to the economy of 69 billion dollars. The population and industrial concentrations mean that the losses the earthquake will inflict upon the USA will be greater than those of any disaster the country has so far experienced.

I interrupted Vladimir Kozlov and asked him to explain the connection between these gigantic geological processes and the aim of our expedition. Kozlov, the chief geologist of the 'Aerogeologia' association, smiled: "Look outside the window."

I saw a low mountain-chain, whose ridges cut across the plane.

This geological structure is called a rupture. Soon you will also see the folds of the surface where it has been crumpled by the fantastic forces of the Earth. The higher the survey over the Earth, the more detail the photograph will contain. From space geologists saw pictures they had never seen before. An unexpected advantage of photographs taken from space was that they revealed the Earth's deep structures. They stood out in the 'cover' of drifts in the same way as the contours of a monument stick out before it is unveiled at a ceremony.

However the programmed work of space automatic machines does not always satisfy the scientists, and, hence, they wanted to acquaint the cosmonauts with the mysteries of the scientific study of the Earth, so that they would be able to conduct more subtle and active research themselves. It turned out not to be an easy task. The period within which the cosmonauts are trained is strictly limited, and one needs years to become a proficient geologist.

What helped was the training method elaborated at the 'Aerogeologia' association. Cosmonauts do not have any textbooks. They learn the subject from aboard a plane by listening to a commentary on the 'living nature' made by specialists.

Since we were already approaching the region where the class would begin, I decided to be a pupil. However, I managed to cope with only part of the task because studying the surface from the height of a plane is only the beginning. Then the same region was analyzed from a helicopter, after which, as the concluding part of the operation, the region was covered on foot, with the members of the expedition actually touching everything with their own hands. In short, acquiring knowledge is very hard indeed. I remembered that Valentin Lebedev and Anatoli Berezovoi actually 'passed' through the whole of the Soviet Union: from the Ukraine to Primorie, along the Baikal-Amur Railway and Central Asia.

S.M. BOGORODSKY, chief of the geological department of the association:

We have dealt with several crews, who later worked aboard the "Salyut-6" and "Salyut-7" stations. The results were quite interesting, in particular their research on the mineral resources of the USSR.

Bogorodsky also recalled the flight of the "Elbruses", namely Valentin Lebedev and Anatoli Berezovoi (1982). The programme involved over 30 geological assignments. The cosmonauts were so engrossed in their work that they did ten times more than what was required. For instance, they investigated the borders of the Astrakhan arch—a steep elevation of the earth's crust. The gas deposits there had been under development for several years. However, the exploration faces a number of difficulties, one of which was that while the borders of the region on one bank of the Volga were clearly observable, the other borders were hidden by sand. The cosmonauts discovered the borderline of the deposit and it became possible to carry out the ground investigations more successfully.

Furthermore information supplied by the "Elbruses" on the presence of geological structures between the Caspian and the Aral seas brought a real sensation. Their observations revealed that oil and gas deposits there seem promising.

The annual contribution to the economy by space geology has been estimated to amount to tens of millions of roubles.

The plane was about to land. The flight had been very special and yet it was routine and preparations for the next flight were in progress.

The Weather Forecaster

I went to my next destination which was the Hydrometeorological Science and Research Centre of the USSR. This was because one of the working professions of cosmonautics is weather forecasting. Since the role played by space flights in this respect is common knowledge, I don't think that I should dwell at any great length on it. Suffice it to mention that annually the economy benefited from the use of space meteorology by over one billion roubles.

I was particularly interested in 'marine' forecasting and visited the President of the Commission of Marine Meteorology of the International Meteorological Organization, D.Sc., *Konstantin VASILIEV*. In his department work was in full swing. Long tables were covered with maps containing the results of observations received using the "Meteor-2" space television system. The photomontage provided data on atmospheric processes, storms and data for weather forecast. The information was expected by thousands of ships in all the oceans of the world.

Konstantin Vasiliev showed me a region in the basin of the Atlantic Ocean which should be avoided by fishermen and passenger ships for a day or two. The waves generated by a raging typhoon there would be eight to ten metres high. I was surprised.

"Can the waves also be seen from the satellites?"

"Of course not, but there is a close relationship between the atmospheric processes of the weather. We infer by analyzing the movement of air masses, the velocity of the wind, visibility and precipitation."

A radio message from the Soviet transport ship "Mikhail Stenko" reported that on leaving Calcutta it had hit a strong tropical cyclone in the Bay of Bengal. It was requesting advice on how to leave the storm as quickly as possible. The ship was in imminent danger.

I watched the researchers work very efficiently and without haste. There was no question of hurry or bustle. The fate of many people depended on their results. Their

reply was soon sent to the ship. Several hours later routine satellite photographs confirmed that the "Mikhail Stenko" was out of danger.

Information received from the "Meteor" series of satellite also helped the "V. Mayakovsky" to accomplish its voyage. It had traversed three oceans dragging a huge floating dock and it is not difficult to imagine what consequences a violent storm would have been had one hit the ship.

UNESCO estimates that weather satellites save four hundred ships a year from disaster.

I asked Konstantin Vasiliev how information from space was obtained.

"When necessary, we ask cosmonauts working in orbit to help us, but automatic satellites supply us with quite a lot of data too. At the USSR State Committee for Hydrometeorology and Control of the Environment Headquarters has been organized to receive and process the information from satellites."

The Fireman

Another researcher in this organization is Galina Isaeva. She is responsible for an important section. Here the words 'fire protection' themselves evoke in the mind of any town-dweller associations such as the emergency telephone call and the headlong rush of a fire brigade down the streets to render assistance. But what can be done in the taiga or tundra when it has caught fire? You cannot make a telephone call to a place where there is no one for thousands of kilometres. Moreover within only an hour a small forest fire can destroy several hundred hectares of forest, which is of value not only for the forest industry but also for the whole environment.

Every two hours Galina Isaeva receives a pile of photographs from space. She focuses her attention on the regions where the probability of fires is greatest. These areas are known beforehand. They have had no rain for a long time and the weather is dry.

For instance, when I was there the information had been analyzed and after a brief consultation with the colleagues a telephone call was made to the central aviation basis for the protection of forests. Shortly after-

wards planes took off from airfields to help the region threatened with disaster.

Emergency rescue teams are transferred from one place to another about one hundred times a year, which is practically once every three days! Such an operation presents major difficulties with parties of firemen being landed, back fires organized, and in some places clouds are seeded to rain on the seat of the fire. The sooner the information is received, the smaller the fire, and, consequently, the easier it is to extinguish. Hence, the satellite information cannot be undervalued.

During a short break in her work Galina Isaeva told me that the satellite information is both sent to us, and distributed over a wide network of autonomous stations scattered throughout the country and to reception centres. The larger, regional ones, are situated in Khabarovsk and Novosibirsk. There are about six hundred district stations. This means the situation can be analyzed and important decisions be made on the spot.

"Are tundra fires as dangerous as the forest ones?"

"Certainly. Herds of deer must be evacuated and the local population warned in good time."

New photographs then arrived and their decoding began.

The Metallurgist

That space helps geologists, navigators, fishermen, meteorologists, and firemen is quite obvious for the simple reason that it enables them to see objects on the ground much better. But can it be useful, for instance, to metallurgists? Isn't everything that has been achieved in orbit has been possible because of extraterrestrial conditions for smelting ore and for chemical and physical reactions? Thus, some substances cannot be mixed on Earth, but in weightlessness unusual cocktails can be made without much effort. Researchers think that hundreds of new and remarkable alloys and compounds can be made in space.

Numerous experiments have already been carried out using the "Splav" and "Kristall" furnaces aboard the "Salyut" stations. Alloys of lead and zinc, and lead and aluminium have been synthesized. However, it can hardly be denied that the construction of factories in orbit is

while not altogether science fiction today is not yet feasible. In the future such factories will orbit the Earth, but what is there to be done now?

I received an answer at the Physics Institute of the Latvian Academy of Sciences.

My guide was the deputy director of the Institute, D.Sc. (Eng.), Yan LIELPETER: In space the quest for new materials is now in progress. A study of samples created in orbit has made it clear that under certain conditions it might be possible to get these alloys on Earth too. In other words, the space technology could be brought back to Earth, as it were. However, it is better to see it all with one's own eyes.

Then he invited me to his laboratory.

The installations developed at the Institute made it possible to actively influence the substances using magnetic fields and so attain the required conditions for smelting.

So far the furnaces are not large and their outputs are not measured in the thousands of tonnes either. There are only a few such smelters but what is important is that the direction of research has been set. New alloys are being sought in orbit, and the conditions for getting them are simulated on Earth.

I held a small oblong bar of an aluminium and lead alloy. It was heavy and smooth to the touch and was something that should not exist according to all the laws operating on Earth. However, now it is not the case. Yan Lielpeter went on to say:

"This alloy is very promising. It has very good anti-friction properties and it can be used to manufacture frictionless moving parts for a machine. This is extremely important for the future."

"And tomorrow?"

"New space launches, new experiments and alloys, which means that there will be another parcel from orbit 'with its own problems' to solve. I think that we are on the threshold of a revolution in terrestrial metallurgy, though orbital factories will certainly start functioning very soon."

Space has ceased to be the domain of a restricted number of specialists. Practically every branch of science is now interested in space. Up till now cosmonauts have been

obliged to become proficient in various new fields; tomorrow, however, engineers and many other professionals will work in orbit.

It must Belong to Us All

An authority on international law, deputy director of the Institute of State and Law, USSR Academy of Sciences, Vladlen VERESHCHETIN, said the following about the international law on space: The basis underlying regulations in outer space is contained in a treaty on the principles relating to the activities of States doing research and exploiting space, including the Moon and other celestial bodies (1967). These principles include the freedom of research and utilization of space by all the countries of the world, the necessity to adhere to the norms of international law and to consider the interests of other nations, a prohibition against the appropriation of space or any parts of it by a State or States, the responsibility of the States for their space activities, and the restrictions against military activities in space.

These general rules were developed and supplemented by a treaty on the rescue of cosmonauts and their return to Earth, and the return of objects launched into space (1968); a convention on the international responsibility of a State for damage caused by a space object (1972); and a convention on the registration of objects launched into space (1976).

Summarizing these treaties we would be justified in saying that no arbitrariness in space is permissible and every opportunity should be provided for national and international activity in space.

Space Law covers many topics. However, many questions remain unresolved. The most important is the prevention of an arms race in space. The Soviet Union has suggested a treaty banning the deployment of any weapon in space. The suggestion was favourably met by United Nations members, but unfortunately, certain people in the USA are ignoring this feeling and are trying to implement the "Star Wars" programme, which is in itself a hazardous step towards the militarization of space.

Economic activities in space are closely related to the use of satellites for direct television broadcasting and

remote Earth sensing. The USSR has suggested to develop laws to exclude the possibility of using the information about the resources of foreign states obtained from space to the detriment of their legitimate economic and defence interests.

As far as the direct television broadcasting is concerned, a session of the UN General Assembly adopted a resolution in which the basic principles for this kind of space activity were determined for the first time.

The Comet's Visiting Card

Scientists have debated a host of hypotheses about the Solar system. For instance, it has been suggested that our system has two suns rather than one. Indeed observers from other worlds would form such an impression, the second sun being the giant planet Jupiter, since it radiates more energy into space than it receives. A subject of heated discussion is however the origin of the planets themselves.

According to some scientists, our knowledge of the Universe will be augmented by a study of comets. It is assumed that their physical and chemical compositions are exactly the same as that of the gas and dust nebula, from which the Sun and planets formed. The primordial substance of a comet has been preserved as if in a gigantic refrigerator up to the present.

Hence, the mission of the Soviet probes "Vega-1" and "Vega-2" to Halley's comet in March 1986 were of enormous interest to the scientific world.

The following is a brief account by Academician Roald SAGDEEV, the Director of the Space Research Institute of the USSR Academy of Sciences, of the completion of the programme to study the comet: The probes were put on course for almost fifteen months. Having travelled over a billion kilometres they approached Halley's comet along an accurately calculated trajectory. "Vega-1" passed within 9000 kilometres of the comet's nucleus, while "Vega-2" got within the same at the range of 8200 kilometres. Fourteen instruments aboard the probes transmitted unique information. More than 1000 photographs of the comet were received. It was the first time humanity

has been able to study such a space body at so close a range.

The designers knew that though the probes were adequately protected, they would still be bombarded by dust particles moving at relative velocities of 80 km/s. So they decided not to store the information and arranged for it to be directly transmitted to Earth. In turn, this meant that the bandwidth of the radio system (its information carrying capacity) had to be increased twenty-fold and the pencil-beam aerial continuously pointed to the Earth.

The information on physical characteristics of the comet's nucleus (its size, form, surface properties, temperature), the compositions of the gas and dust particles, and the interaction between the Solar wind and the comet's tail and ionosphere were processed by computer.

Professor Vasili MOROZ, head of the planets department at the Space Research Institute of the USSR Academy of Sciences told me what we have derived from observing Halley's comet at such a close distance: One hypothesis about the structure of the comet's nucleus was confirmed. The nucleus is a huge (measuring several kilometres) lump of ice irregular in shape. The Sun's heat evaporates the ice, and the impurities in it are thus released. Under the pressure of the light and solar wind (a flow of plasma) this gas forms into the comet's tail. The hypothesis that the comet's nucleus had a small density and was an agglomeration of small bodies has been found to be untenable.

A number of the images produced by the "Vega-2" seemed to be evidence that the comet's nucleus had two parts. The "Vega-2" was acting as a space patrol. It specified the trajectory along which the probe of the European Space Agency "Giotto" passed within 600 kilometres of the comet's nucleus.

The international "Venus-Halley's comet" project was a cooperative venture by scientific organizations from the USSR, Austria, Bulgaria, Czechoslovakia, the FRG, France, the GDR, Hungary, Poland, and the USA.

Tsvetana GOGOSHEVA, a senior researcher from the Central Laboratory of Space Studies of Bulgarian Academy of Sciences: Scientists have long been concerned with the hypothesis that comets influenced the origin of life on

a planet, and particularly on the Earth. Using a three-channel spectrometer developed in Bulgaria, France, and the Soviet Union we managed to get interesting data on the composition of the nucleus and the tail of Halley's comet. The first conclusions revealed that there were hydrocarbon components, hydroxyl and cyan molecules.

Thus the hypothesis that organic compounds are brought to Earth from space has again become a subject for discussion.

V.I. MOROZ says on the origin of comets: It is suggested that there is a region far beyond Pluto's orbit from where comets move into the Solar system. This region is called the Oort cloud (in honour of the Dutch astronomer Jan Hendrik Oort).

Only a few comets leave the Oort cloud and periodically appear in the sky. It is considered that Halley's comet acquired its present trajectory approximately twenty thousand years ago. People on Earth will be able to watch it for another ten thousand years or so after which it will have lost its mass.

R.Z. SAGDEEV: The "Vega" probes have done much work for scientists. Unfortunately, they will never return to Earth, but they did accomplish their task. I can add that due to particle bombardment "Vega-1" lost 45% of its energy and "Vega-2" experienced greater losses. However, the probes continue to exist and even though they have parted from Halley's comet and are moving into the expanse of the Universe, they keep sending information back to Earth.

Chapter III.3

AN UNUSUAL SITUATION

A.NEMOV: The romantic side of the first rocket launches is superseded by everyday space work. Doesn't this belittle the contribution of those who have chosen cosmonautics as their profession? Once in a while this kind of question can be found in 'letters to the editor', and they must be answered too. For several months, usually after ten in the evening—the cosmonaut's daily schedule was very heavy—I interviewed Georgi Grechko. We

would sit opposite each other and the tape-recorder would start working. We only talked about the particular mission.

The Offer

Georgi GRECHKO, twice Hero of the Soviet Union, pilot-cosmonaut of the USSR: It was a very strenuous day. For several hours running the cosmonauts and ground control had been working to get their ship to dock with the "Salyut-6" station. The tension at the control centre was reaching saturation point. We didn't want to believe that our ambitions could be frustrated. The station was of an absolutely new type. Two docking hatches serve to guarantee that it could function for a long time by allowing the docking of the "Progress" transport spaceship. The crew had prepared for a long flight. The programme included hundreds of experiments and there was a chance that the flight endurance record could be beaten. But space is space and anything can happen. Ground control was compelled to make the undesirable decision to prepare for the cosmonauts to return to Earth.

We left the flight control centre in a very depressed mood. We were sorry for our comrades and for cosmonautics as a whole.

When I arrived home, I saw my wife in tears. I didn't feel very cheerful myself and the situation was aggravated by her tears.

"There, there. Stop crying! Isn't it more important for women that their husbands return home? Well, the docking didn't take place, but tomorrow the boys will be back on Earth hale and hearty. They might have remained in orbit for much longer."

"I'm not crying because something went wrong with the docking," replied Maya, "I'm crying because it will now be your turn to fly."

Her words surprised me.

"What do I have to do with it? There is an alternate crew. I'm in the third team."

But she continued to cry and went on saying:

"I know they will send you now."

Sometimes the heart of a woman can predict things

better than the inflexible logic of the mission, the programmes, and the proper sequences. Several days later K.P. Feoktistov came up to me at the control centre and said:

"You have been recommended for the flight."

I remember that my only question was:

"Who with?"

"Romanenko."

Only book on cosmonautics can tell you how thoroughly crews are chosen. Groups of psychologists work on the problem. Tests are conducted on psychological compatibility and experiments last for many hours. For instance, one questionnaire which every cosmonaut has to fill in contains 500 questions. So the problem of choosing the members of a crew is not easy. Thus asking me whether I would fly with Romanenko surprised me. I had to answer.

I started thinking. What was Romanenko like? We had not met often during classes. I remembered he had an open pleasant face, he was active and seemed as interested in underwater hunting as I was. I also remembered that he was not indifferent to the English language either he was fluent in it, or he couldn't stand it.

I spent about thirty seconds on trying to remember all I knew about him. Then I said:

"OK!"

We had to wait for a final decision. Later I found out that several other cosmonauts had been asked to take part in the "Salyut-6" expedition.

Why after the failure of the first crew had their alternates not gone? The authorities thought that after a failure the crew should have someone with space experience, docking in particular. This, they felt, would give him more confidence in case of emergency. This was why they wanted one of the alternates, who knew the flight programme perfectly well (it was Yuri Romanenko) go into space with an 'old-timer', and it was why K.P. Feoktistov approached me.

When his offer became known to my colleagues, I remember one said:

"Why should you go on such a long flight? Let young people who have not yet been in orbit have a go. Those wishing to become cosmonauts will do anything to under-

take a flight. You have had your mission, so you can choose any mission you want."

He may well have thought he had the best intentions. A three-month mission was in the offing. After 63 days, which was the record Soviet cosmonautics had then achieved, it was necessary to reach the 96-day level. It seemed a heavy task. Subconsciously, I felt that three months was rather a long period of time.

I answered the man frankly:

"I adhere to a principle borrowed from Grinev, the protagonist in Pushkin's *Captain's Daughter*. 'Service is not to be asked for, neither is it to be rejected.'"

My colleague shrugged his shoulders, which showed he had failed to understand me, and we didn't touch on the subject any more.

Soon it became clear that the mission would be really difficult from its outset. Analyzing the data from the unsuccessful docking of the spaceship and the station, the engineers concluded that the "Soyuz" and "Salyut" had in fact twice come into contact. It was quite obvious that incorrect contact between the seven-tonne spaceship and the 18-tonne station might have had bad consequences for parts of the docking unit. Moreover the joints which would ensure electrical and hydraulic continuity of the "Soyuz" and "Salyut" might simply have been destroyed. This would mean an emergency exit into space and not through the exit hatch in the station, but through the craft's docking unit, which was not meant for that purpose. Besides, it would have to be done in spacesuits which nobody had as yet tested in open space.

It so happens that you prepare yourself for the mission during several years, only to remain in orbit for only one month (this was the case with me when I made my first flight with Alexei Gubarev). Now I had two months to prepare for the mission that would last three months.

The Examination

From then on I was on a very special schedule. Classes, training, training, and classes again. I seemed to have been spreading myself thin and yet I still didn't catch up with everything. I remember the day before the examination. I had been studying since six in the morn-

ing, and at ten in the evening an adviser came to see me, two hours later another one came, and at two in the morning, a third favoured me with a visit.

My exam began at nine in the morning. The night before I had envied Yuri Romanenko, who as an alternate had already passed the examination. Whether I would fly or remain an alternate depended entirely on how I would cope with this examination.

In the spacious hall the tables were placed in a semi-circle at which the members of the examination commission were seated. A small table with a place for me stood in the centre of the hall. I saw a pile of blank sheets of paper and some pencils. For the first time I was happy that I had never relied on cribs. Relying entirely upon myself eventually brought its results.

The hands of the clock moved steadily forwards. The commission members alternated, only I remained. I did not take umbrage at those who were particularly meticulous. I knew that space tolerated no errors.

The development of space technology follows its own path. There was a time when the automation aboard the spaceship had the main role. The very first assignments cosmonauts were given involved, for instance, an attempt to eat or drink, or to look through the window, or to get out of their seats. This was when we were only trying to find our way in space and understand the function that man could perform in its development.

Those flights had different programmes. The scientists were aware that the safety of the cosmonaut depended on the automation rather than on the cosmonaut. The flights gradually became more complicated and the research programmes were getting more extensive. Manned spaceships were becoming to serve their purpose to an ever increasing extent. It was now possible for cosmonauts to control them and docking could be practised manually. Thus, the role of cosmonaut on the mission became more important and together came the price of a mistake.

Hence, if at that time 'scraping through' an examination had not been censured, the new programmes called for a different attitude to studies. A superficial knowledge was now seriously penalized. Moreover, if during the mission, for instance, you mishandled the life support system (which, unfortunately, sometimes does occur), the teach-

er who had taught you and who assessed you at the examination and let you go into orbit was also made responsible for the mistake.

I had waited for my first flight for nine years. Six times I had been an alternate on different crews, six times I had taken space examination sessions. During that period I have seen how the attitude to examinations had altered. They had become cross examinations and one was obliged to answer the questions coming from many highly qualified experts.

My examination finally ended at six in the afternoon. The doctor responsible for the crew came in and said: "Another hour of this interrogation and even if he receives your permission to go into space, we shall not allow him for health reasons. We can't send exhausted people into space."

He took me by the hand and led me to the door. I remember that one of the examiners jumped to his feet and ran after us. We walked on while he continued to ask questions. I understand that he had not had enough time to ask me all his questions and he was now doing his best to make up lest he should be made responsible for my 'incompetence'. I saw that he was right, though it was not easy.

The examination completed the preparations. We flew to the cosmodrome. The day before the launch the crew always meet friends, experienced cosmonauts, and those responsible for the programme. They try to encourage you and give you last instructions. I remember one person said.

"Now, guys, do only the docking and nothing else."

At that time I did not understand why our crew was receiving such instructions: looking back I can see that what lay ahead of us was a record-breaking, long, complicated programme.

The Exit

Oh, how very slowly we prepared the station and ourselves for the important extravehicular activity so as to check the condition of the second docking joint (we had docked our "Soyuz-26" to the first one). The whole

programme depended on it. If during our exit we found a defect that could not be eliminated, then another spaceship would be unable to dock and there would be no question of breaking any record!

In orbit we were immediately confronted with problems not contemplated on Earth.

We were to exit into space through a hatch that was not meant for that purpose. An important aspect in a space walk is to make each movement after fixing oneself in a given position, otherwise one careless step in space, where there is no top or bottom, and you are whirled and carried away. This is what weightlessness is. That was why at the station's exit hatch there were many handholds and cramps. The docking hatch had none of these and we were obliged to install soft handholds ourselves. We used surgical tape to do this. We had prepared for this. However, on Earth, when working on the simulator, we had forgotten that aboard a real station the passage to the hatch was blocked by instruments that had sharp edges. Our spacesuits were made of soft material that could be easily caught on them or torn. We had to dismantle some of the instruments and store them in the next compartment, while the others were covered with porolone. Time was mercilessly moving on.

At last we started our training. We went into the transitional compartment and pressurized each other into spacesuits. They were relatively comfortable, and resembled metallic suit-cases with flexible arms and legs. After opening the lid (which was later hermetically sealed), one had to squeeze into it. It is difficult to imagine what might happen if you faint inside one.

Once, when we were feeling low (between bad and very bad as we used to joke in the first days while we were getting used to weightlessness), I decided to raise our spirits by having a little bit of fun and 'open' the exit hatch without having our spacesuits on.

So I moved into the transfer module with Earth closely watching me from the television camera. Then I started turning the handle of the hatch not imitating the process as was set by the rules, but actually turning it. I did it as if I had always wanted to go out into space without a spacesuit. I heard the operator on Earth shout with surprise. Of course, he realized that it was impossible to

open the hatch because of the station's internal pressure, but reason does not always follow what one sees, and he saw me taking off the last locks that separate the people from vacuum. Anyway, it didn't take him much time to understand that we were teasing him.

In spite of all our efforts, we began falling behind the schedule for leaving the ship. The amount of work to be done was far greater than we had imagined. The mission control officer then asked how things were getting on. Yuri and I said quite frankly that it would be better to put off the space walk for a day or two and that a bit more preparation would help us. The officer agreed, saying that although we could certainly take another day or two, radio visibility between us and the Soviet Union would mean that they would be unable to watch the space walk by television. In other words, we would be beyond their help and they would not know what we were doing. The extra days for preparation were possible but it would be better to do without them.

We discussed the matter and decided not to press for our request.

The great day arrived. According to the programme we prepared the station for an emergency escape. This meant that if the hatch which we would open could not be closed, it would be necessary to depressurize the whole station, reach the spaceship through it, prepare it for landing, and deserting "Salyut" return to Earth. The station would then be doomed to perish.

We decided to 'burn our boats' and not to prepare the station for an emergency escape. We decided we would stay in the station at any price, we did not want to think of an alternative.

Thus, wearing our spacesuits we found ourselves in the transfer module. The first thing was to check the oxygen bottles. The manometer on one bottle did not react when the valve was opened. What could have happened? We had already lost 20 per cent of the oxygen.

Problems gradually multiplied. As the pressure in the compartment began to drop my spacesuit quite unexpectedly whistled, started bulging and squeezed my leg like pincers. I felt it become dumb but there was really nothing I could do about it. I saw that Yuri was having exactly the same problem with his arm.

Under the circumstances one cannot but complain of the dimensionless spacesuits. We only had two at the station, and how many tall or short, thin or stout cosmonauts would have to use them in the future. They can be only adjusted to a particular size by squeezing one part of the body into some place within the suit while another part of the body gets stuck.

Trying to find my way between the umbilical cords (they connected us with the station during the space walk) I approached the hatch. Turning the handle I unlocked it. The 'door' to the void could be opened.

Since there was no device to do so, I had been given 'master key' made of titanium. With a trained movement I tried to lever the hatch up. It went two centimetres loose and then stopped dead. I made a greater effort. The hatch wouldn't move. I could not understand why. The compartment was practically airless. I called Yuri. He tried to help, but the hatch wouldn't move at all. The work was so strenuous that sweat poured down all over us. Time was flying. Finally our last desperate effort was successful and we opened it. But it crossed our minds that if we left, spend our oxygen working outside, then return to the station, we might not be able to lock the hatch. We could have judged the situation to be dangerous and we could forgo the space walk to maintain the integrity of the station. In that case the programme, the efforts of thousands of people, would be thwarted by this unfortunate hatch.

When people consider the difficulties inherent in our profession, they usually stress *g*-forces. Truly four, five, and even greater *g*'s do develop during landing but a properly trained cosmonaut copes with them. It is not the *g*-force that matters so much, nor the difficulties of the examinations, nor the underwater training to simulate a space walk, nor even the possibility of having the rigid gloves of the spacesuit rub the skin off your hand to blood after one and a half hours work, the real difficulties are quite different.

They turn up when you have to make the decision on your own, a decision upon which so much depends.

We decided to go out into space.

I swam out of the station, wishing that I could look at the Earth, but there was no time. We had to work. It was

now important to see whether the docking unit could be readied for the reception of spaceships.

Two hours later we took off our spacesuits, and had it not been for the weightlessness, we would have collapsed. However, the unit was intact, which meant that the mission could go ahead. It was hardly credible then that Yuri and I would have to make a more difficult choice only one minute later.

"Flight Control Centre is calling," said Yuri.

This space flight was more difficult than the first one, but more interesting.

Chapter III.4

THE SPACESHIP PILOT

The Launch After the Take-Off

Igor VOLK, Hero of the Soviet Union, Honoured test pilot of the USSR, cosmonaut: The black velvet of unfathomable space with its haphazardly scattered shining stars blinked for the last time, and the spaceship rushed towards the Earth's rainbow. I could very well imagine our triangular supersonic craft submerging into the blue bowl of the Earth's atmosphere, and after playing ducks and drakes upon the gaseous ocean would make a rapid headway downwards. Gradually the familiar contours of the continents were becoming blurred. Sparks flushed on the windscreen. Now the spaceship, flying at several kilometres per second, would turn into a burning bolide. Thin fiery streams ran along the wings, reaching the cabin, and the windows shone brightly at first, as if TV sets, only to become crimson afterwards. The *g*-force pressed me into my seat. The fuselage vibrated slightly. But most unpleasant was the raging fire that continued to roar outside the multilayered superstrong glass, the sound reaching my ears even through the spacesuit.

Then all of a sudden everything stilled. The burnt glass came off the windows. Through the sparse clouds I could see the outlines of the Caspian and the gray ribbon of the Volga. At fifty meters the spaceship began to glide to Earth along a long flat trajectory. The board computers went on correcting this noiseless flight. The task was not

simple; suffice it to say that this 'space plane' did not have any ordinary engines.

At long last the concrete strip was reached. The landing approach was exact, the plane stopped, and only when I took my hands off the control wheel, did I realize that my plane was just an ordinary Tu-154 and everything else was no more than imagination. So far... though several hours ago I had actually come back from space aboard a "Soyuz T-12" transport spaceship together with Vladimir Dzhanibekov and Svetlana Savitskaya. Whereas the space flight was over for them, I still had not finished. According to the programme I had to fly several different types of planes immediately after the landing. Experts were assessing my abilities as a pilot after being in weightlessness for twelve days.

Then came the last minutes of a television interview beside the burnt "Soyuz T-12". Finally, the television people waved their hands and shouted, "We've got it." Vladimir Dzhanibekov and Svetlana Savitskaya went aboard the helicopter and started for Balkonur. The journalists flew off in their wake. I was relieved of my space-suit and had to undergo an orthotest while standing, sitting, and lying. I showed no signs of losing consciousness.

The blades of the helicopter that was to take me to Dzhezkazgan started to turn when there was a slight hitch with the flying equipment. They were all in a hurry and forgot to prepare it. The space-suit was taken off, but I had hardly anything to wear, so I was obliged to use spaceship's emergency reserve. It contained a fairly good flying suit, though shoes were a problem—there wasn't a single spare pair. The aircraft commander yielded his position and the moment I took the control wheel firmly in my hands, all my anxiety vanished. I felt immediately at ease with the blue sky all around me. We landed on the airfield in Dzhezkazgan. The Tu-154 laboratory plane with its engines running was already on the main runway. I left the helicopter and ran to the Tu-154. Those watching me were very surprised to see me barefoot, but I had no time to explain. After all, does it really matter whether you are properly dressed?

The plane was gaining speed to take off from the main runway and I found myself once more at the control

wheel. Several hours later we were flying over Volgograd. Evening was approaching. It was time to land. How fascinating it all was. That morning I had been in space, aboard the "Salyut" orbital station, orbiting around the planet every one and a half hours, and by evening I was landing an airliner on an aerodrome. The aircraft touched the concrete runway.

Another change of the plane. I ascended into the cabin of a supersonic MiG. After a short take-off, the city with its yellow lights quickly disappeared under the wind and in front lay the thin streak of crimson horizon. The supersonic aircraft speared into the sky. Then came the landing approach, this time guided by instruments. The landing lights of the concrete runway glimmered in the dark. I taxied into the aircraft hard standing and opened the cockpit. The night air was cool, and I was seized with a desire to walk and lie in the grass, looking at the starry sky. However, I had to go back again to Tu-154 laboratory plane. This time I was a passenger. In the passenger compartment the doctors got hold of me once again, but I was heedless to what they measured and what they said, I knew I had completed my assignment for that day. Fatigue was beginning to exert its merciless hold. I was aware that the medical tests would be resumed in Baikonur.

As I was dropping off I caught myself subconsciously analyzing every small aspect of the flight. It made me feel content for it meant that I was on form.

The Aim I Chose

I think that I have nothing to complain of. After graduating from the Kharkov Road Transport Institute my father was given a job in Ussuriisk in Primorsky region. Thus, as a child I knew nothing of fences or stone mouse-traps, as the city's cramped courtyards are called. I would get to the top of the hills through the thorny shrubs and there I seemed to be as high as the clouds. For hours on end I could walk aimlessly in the Taiga, drinking in the freedom, and thinking that it would last all my life. My ambition was to be a peripatetic geologist. We, the boys of Ussuriisk, knew quite a few ways of lighting a fire with a single match, how to tell the direction from

the trees, and which wild berries were edible. Playing at geologists, we firmly believed that the main principle of our profession was the right to choose. For in order to find and do something that nobody has done before, you must pave your own way. 'To follow the untrodden path.' I don't know what fate awaited my playmates, but I think that each struggled for the right to choose.

When I was in my eighth year at school my father went to work to Kursk in Central Russia. When we left Ussuriisk, I hardly imagined that I would not return to the Far East for twenty years.

It was in Kursk when I first saw jet planes. The airport was near the city and when planes were landing or taking off, they flew low over the city's park. The wild noise of jet engines was simply fascinating. All of us, the senior formers, were of the opinion that 'propellerless' planes were the most modern technology. As is common to say now, technology on the brink of fantasy. When a representative of the aeroclub came to visit our school, all my classmates and I became members immediately.

The reaction at home was not enthusiastic. After hearing me speak about the aeroclub my father said: "Well, if it interferes with your school studies, you will have to give up the planes."

It turned out that the club demanded quite a lot of work (no less than at school). We had to learn the design of planes and engines, and moreover take care of the equipment. Some of us found it too much and it was difficult to watch your friends go to the cinema or to a dance, when you had to stay with a piece of cloth and clean oily engines, or polish the tail unit of plane dirtied from engine exhaust. But our instructor at the aeroclub would say, "First comes the cleansing cloth". The number of 'future pilots' at our group steadily decreased. For those who remained 'the stairway to the sky' was a driving ambition. My father's anxiety proved to be groundless. My school report was as good as it had been before and at the aeroclub I became an excellent student.

The school-leaving examinations flitted by to be succeeded by a wonderful period, during which we, the aeroclub students, lived in tents near the airfield. We devoted all our time to the planes. Was it worth thinking of anything else? However, there was one thing that de-

pressed me very much. I was to go to Kharkov. Only my close friends knew that I had yielded to my parents' wish, who wanted me to graduate from the Kharkov Artillery Radio-Technical Academy.

My parents' generation had borne the brunt of the Civil and the Second World wars. They were still fresh in their memories and it shaped a single thought, that boys were meant to be soldiers. In my case, it could not have been otherwise, since my mother's eldest brother had commanded a revolutionary regiment during the Civil War, her elder brother, after having been wounded at the Front, was a lecturer at the Suvorov Military School in Kiev, and her younger brother, though a physician, had been with the forces throughout World War II. In addition my father's brother was in the Air Force.

On the eve of my departure I did not sleep. I felt that I was making a mistake since artillery had never featured in my ambitions. The future seemed bleak with nothing to make me feel happy. I had once experienced the same feeling, when I heard of Stalin's death. It seemed to me then that life was not worth living. Frustrated as I was, I failed to notice that my father, whose friends had been arrested in the nights of 1937, 1938 and later in 1949, did not shed a single tear at the death of the leader. I was not yet aware of the truth. The Twentieth Party Congress was only approaching.

Early in the morning, after parting with my friends, I stealthily left the camp, lest our instructor, whose opinion I deeply appreciated, should have seen me.

My friend and I arrived in Kharkov, reported to the Academy and submitted our papers. We passed the examinations, which we were granted the permission to take, without difficulty. However, this did not make us any happier. Besides, right above where we stayed, we saw a "Yak" plane making a beautiful turn. It was probably graduates of an aviation school paving their way into the sky. We did not hesitate much longer. The choice was made by morning. We packed our things and we would, without saying a word to anybody, run away, thus completing our career as artillery officers.

The windows of our room, which accommodated some ten young men about to enter the academy, overlooked the city park. We knew that the house was guarded, and

so the window was the only exit accessible to us. That it was on the third floor was no impediment. First we threw down our things and then I jumped myself. When my friend's turn came, he lingered and hung on without releasing his fingers. I told him to hurry up. The soldier on duty heard the noise with the result that my friend fell practically into his arms. Two hours later we were given back our papers, which made us feel as if we had been relieved of a burden. I knew that I could explain everything to my parents. In the long run one could become an officer even by graduating from an aviation military school. The most difficult problem was how to get inspector Yuri Kozyakov pardon us and let us return to our group.

When he saw us, his manner was quite reserved. He said that if the commanding officer gave his permission, we would be allowed to proceed with service, if not ...

The commanding officer did grant us permission, but my first and favourite instructor for a long time regarded us as 'traitors'.

In a month's time I completed my studies at the aeroclub. I wanted to join the combat aviation school (in those days there were such educational establishments), but I was destined to continue my studies at the bomber aviation school. I could have waited a year, but I did not want to lose time, and thus I made my choice. A bomber is also a plane, isn't it?

I remember the commanding officer of our aeroclub, an optimist at heart, who never tired of repeating to all those who dreamed of high velocities, "What do you see in a fighter, my blind kittens? Five to ten years of overloading and that's the end of you. But a bomber is a life-long service."

A Two-Point Landing

It was with great difficulty that I got accustomed to the strict schedule and rigid discipline of a military school. For practically the whole year I argued with the officers, trying to win the right to take decisions; I had to spend quite a lot of time in the kitchen. Gradually the conflicts were forgotten, and it was not your temper that deter-

mined their attitude to you, but your own attitude to the service.

In the last year, during the examination flights my skills were tested by the deputy commanding officer of the school, who was responsible for flight training. After the flight, he left the second cabin, smiled, and without saying a word, shook hands with me. I graduated from the school with honours. After the final examinations, all the students were blissfully happy. Any day we expected to be promoted to the rank of officers. All of a sudden news reached us that a meeting of the graduates had been called but that not all of us would be invited. But who would go? The foreboding did not leave me for a minute. All day long we did nothing but wait. Fifty of us were not allowed to attend the meeting and I was one. However I felt that my fate would be decided, and so I had to attend.

I can still remember that moment. The hall was packed and one could hear nothing but the din of excited voices. It suddenly ceased when we saw our commanding officer and other military officials, presumably from Moscow, take the stage. Our commander started to say something incoherent about the international situation without raising his eyes from the floor. He concluded by reading out loud the order that all those present would be demobilized. The noise in the hall was deafening. Everyone wanted to say something. The commander called everybody to order. Then the man from Moscow took the floor. He explained to us very clearly that the armed forces were being reduced and that the country did not need so many military pilots. He told us not to worry since all of us would be given jobs in civil aviation. He gave the floor to their representative, who began by saying how wonderful it would be to fly passengers and the country's freight to every part of the world. No one else had anything to say on the subject. Some graduates wept.

Nobody slept that night including me, even though I was one of the fortunate ones. I was still destined to fly my military planes. Soon I left for the Caucasian military district.

As regards my first regimental commander, luck was on my side. He was an excellent pilot and I remember he noticed that when landing my plane on the main runway,

I took time lowering the front wheel onto the ground. According to the instruction this was prohibited. However Colonel Yermak did not penalize me, and instead asked me to walk with him around the airfield, giving me an edifying talk on how some pilots violated the boundaries of the runway, which had already led to several accidents. I tried to convince him that I would not do it since I had learnt to alter the centre of gravity of the Il-28 by repumping the fuel, and could not only cover the whole runway with a raised wheel, but could also taxi directly to the hard standing. In other words, I was not violating instructions out of ignorance, but was doing so consciously. We argued quite a lot about my landings, and even so I was one of the first whom he sent for further training. Again I was to travel ... I had to change for a more modern Tu-16. When parting, my commander told me that I probably belonged to the category of pilots who simply could not stop playing tricks aboard a plane. I did not want to argue that at first I had worked out my landing style in detail, and only then began to work on it in the air and on the strip. Step by step I brushed up the technical aspect of piloting.

Our group completed the training course in half the time it took the rest. We were captivated not only by modern technology, but also by the possibility of doing everything on our own. My friends were second pilots. So was I, but each of us secretly dreamed of becoming aircraft commanders. 'Tu-16 Commander'. The words did have a certain ring at the end of the fifties.

At that time many excellent pilots who had previously been commanders were not taking charge of the Tu-16 planes. My prospects of becoming a commander were zero. The rank of second pilot was also a rung towards the commander's post, but there was a time limit, which we all knew about, after which a second pilot became 'a failure' and would remain a second pilot for the rest of his life. My record as an assistant commander was approaching the critical deadline.

Then I decided to change my modern Tu-16 for the Il-28, and thus become independent. The airfields began to rapidly succeed one another. I would receive a military assignment and would fly my bomber thousands of kilometres. My crew consisted of four people, the commander

(myself), the navigating officer, the radio operator, and the mechanic, in case of emergency, since we had to land at different airfields. Often we were quite alone in the sky for hundreds of kilometres. I was particularly fond of such individual flights, as there was no one to restrict our independence. I was responsible for the aircraft and the lives of my crew; I took all the decisions.

Sometimes we towed targets for interceptors to shoot down. I knew that the training was essential for my colleagues from the anti-aircraft forces, but dissatisfaction began to creep back into my life. I decided to continue studying. I spent my holiday in Moscow where I tried to enter the All-Union Mechanical Engineering Institute on a correspondence course. I thought that a profession connected with aircraft production would be useful at work. However, I could not even apply there. In accordance with the rule, military persons were not permitted to graduate from civil higher educational institutions. The only way to study was to enter a military academy, but my rank did not allow me to do so—one had to be a commander. Therefore, all plans of continuing my education had to be postponed.

I might have carried on in the service had two events that radically changed my life not occurred. The first was when test pilots from Moscow came to our unit. They were billeted at the hostel where I stayed, and one evening they spoke very enthusiastically about their work. I remembered everything they said.

I took my final decision in 1962. The army was experiencing 'dark-days' again. With the advent of rocket era, someone decided that planes had forever lost their prestige, and that rocket technology would replace them wholly.

The personnel departments presented a horrible picture. Experienced pilots who had served throughout the Second World War and who were only two or three months short of their pension were ordered back into civilian service. They were divorced from the sky and from what they loved most. Some wept, while others bodily attacked the personnel officers, thinking them to be the root of the evil.

My turn followed suit. I went to Moscow, hoping to see the renowned woman-pilot Valentina Grizodubova person-

ally. She was then the head of the Flight Test Institute.

I got her home address, found the house, and the flat. It turned out that I was not the only one who had something to ask of her. There were teachers, farmers, and mothers of many children. They all came to her for help.

Late that night I sat with Valentina Stepanovna in her kitchen, drinking tea, over which I told my history. She kindly agreed to help me. By the next day I was already on my way to receive the required recommendation to join the test-pilot school.

I can still remember the red tape that hindered my movements for a long time. In order to change work it was necessary to have a passport and a military identification card. The militia refused to give me a passport because I was unemployed and I had no military identification card, but I could not get the card either, because I didn't have a passport. I had no other papers except a Party card, and so I went from one State organization to another in fruitless quest of the truth. Then I went to the Ministry of Internal Affairs. I managed to see a colonel and asked him what I, a Soviet citizen who had just been demobilized, should do. He listened to me very attentively and wrote something on a slip of paper. An hour later I received the document which endorsed my Soviet citizenship.

The Altitude

I had dreamt of the Flight Test Institute and my dream came true. After graduating from the test-pilot school I found myself among those who were working for the future of aviation.

I can still remember my first assignment. It was necessary to expand the limits of the fighter-plane MiG-21 (to approach the speed stability boundaries). We had to reach a speed of approximately two and a half thousand kilometres an hour.

Preparations for the first flight took me some time. Once again I paid special attention to the control system, and refreshed my memory of the theory. The graphs showed that everything would change with the increase in speed, but I could hardly imagine what would actually happen during the flight: nobody had ever tackled that limit before. In the early morning mechanics and engineers

were running about, testing the sensors and the automatic recorders. Every single second of that flight had to be recorded. The delta-winged MiG was rolled on to the runway. Dressed in a flight suit I took my place in the cockpit. The engine started and its roar deafened the whole airfield. The MiG took off.

I rapidly gained the height, the sound barrier was broken. The speed indicator hit the limit mark, after which I was in the unexplored. All of a sudden I felt my leg treacherously trembling not merely because I had to press the control pedals more forcibly. I tried to pull myself together. Nothing availed. There was no question of returning. The planned speed approached. In just one second the plane with the triangular wings was covering almost a kilometre of space. I was surprised that nothing extraordinary was taking place. The main fuel reserve was quickly consumed and I turned the plane back towards the airfield. But the treacherous tremble still lingered in my mind.

Next day I had to fly the plane again and again I lost control over myself. At one moment I thought that if it continued, I would have to give up testing altogether, since my assignment was not that difficult.

In the evening I thoroughly analyzed the flight. It turned out that there were things beyond me. It was then that I understood that I had not learnt everything at the school for test pilots. I had to go on studying and training. But how? The only way was to fly as much as possible, without slighting the weather scan flights, test flights of the planes, and other things. First, however, I had to complete my assignment and then I could train myself.

It was during my training flights that I noticed the strains I fell victim to. The muscles in my arms, legs, and back—all grew stiff. How could I make a correct decision in case of emergency if I was in such a state? The answer could only be in the negative. That was why I made every effort to overcome the tension. I trained myself to relax during the flight and to feel unrestrained.

When I went up into the stratosphere in high-altitude planes, with my space-suit on, and heard my own breathing, I began to think why it was so irregular, and decided to watch it closely. After several training flights it became even.

As time went by and when I became convinced that I had mastered my reactions, I really felt a conqueror. Even the most difficult flight would give me a certain satisfaction. Whereas before several hours of flying used to make me tired, I could now stay at the control wheel for half a day without even thinking of a respite.

In a number of cases, when I found myself in a difficult situation, I managed to succeed and was always pleased to think of my training. Sometimes I instinctively felt how the plane would behave. I remember a spin flight in a fighter. At an altitude of 11 kilometres I entered a spin. I immediately saw that many difficulties lay ahead. With each second the plane was losing a hundred metres of altitude. It was time to get out of the spin. I tried to avail myself of all the possible means to do it; I used the wheels, but the plane, approaching the Earth, continued to turn round and round. At the height of 4 kilometres I knew I would have to eject, but at that very moment I felt my plane behaving differently. The spin started to slow down. The altitude fell from two to one and a half kilometres, and then to one, then the plane was brought under control by the control wheels and was once more horizontal. I was only 400 metres above the Earth, but one could hardly think of that.

There were also bitter days in my work, when fate robs us of friends.

Once some French pilots came to visit us and at Domojedovo airport they did aerobatics at low altitudes in jets. It was decided that we would pay a return visit.

A group of experienced pilots was organized, and regular training begun. It was during one such rehearsal that misfortune befell us. We watched as a plane crashed to the ground. The pilot had been going from one loop to another at an altitude of two hundred metres, which was why he could not eject. He had only two seconds for a decision. They sufficed him only to grow grey at the age of thirty.

We suffered the loss of our comrade very deeply and in his memory, as it were, we gave a brilliant performance of Soviet flying in France. Some may argue that the risk was not worth it. Well, there is risk whenever new planes are tested. Why do aerobatics at low altitudes? It is necessary not only to test a new technology, but also to understand

the extent to which the aircraft can be used. Hence, the progress of aviation in any country is often assessed by their results, the performance of their pilots, and their flight records. Progress in aviation always costs dearly. I lost a favourite instructor and then a friend with whom I had worked shoulder to shoulder. Their deaths were not the result of some stupid and futile undertaking. They fell like soldiers in a battlefield, and when I fly a new plane into the sky, I take forward what they had been doing.

In the seventies, I was offered a new technology. "That's exactly what I want," I thought at once. The aircraft would be even more up-to-date than the spaceship, and combine all the innovations developed in aviation and cosmonautics—a reusable space vehicle (shuttle).

We began to form a group of test-pilots. I wouldn't say that everyone willingly accepted the offer. They understood that a very careful choice and the medical commissions would not only hinder their career as cosmonauts, but might also prevent them from carrying on in their present duties. In fact only nine out of 500 pilots were selected, and some were ruled unfit to fly altogether!

This was followed by a hard training programme. Months and years had passed. In 1984, as I have already said, we reached the stage when members of the programme began performing in actual space flights, though so far only aboard the "Soyuz T-12" spaceship. This was when I had to work in weightlessness.

In 1987 Anatoli Levchenko, another participant in our training team, went into space. Like me, he too had to fly different planes after his space flight.

It is not easy to create the technology of the twenty-first century, but it is a real happiness to have so fascinating a task.

Chapter III.5

THREE HOURS OF UNCERTAINTY

It seems that April 12, 1987 will remain in the memories of many Soviet people. On that International Day of Aviation and Cosmonautics those in whose honour the holiday was held were unable to reminisce; they were anxious about the current events. The cosmonauts Yuri Romanen-

ko and Alexandr Laveikin were making their emergency space walk. Their actions would determine the plans for the immediate future. They had to get the orbital module "Kvant" and the station "Mir" to dock and if it didn't, then it would be necessary to accept that the programme would have to be abandoned. And then it would be required to decide the fate of "Kvant" (to leave orbit and 'die' in the upper layers of the atmosphere), with the same destiny probably awaiting the "Mir" if docking unit was damaged. No one wanted to contemplate those thoughts at the Control Centre on April 12! The flight which later became Yuri Romanenko's feat is narrated by *Alexandr LAVEIKIN, Hero of the Soviet Union, pilot-cosmonaut of the USSR.*

The Failure to Dock

It so happened that over the years I have worked at the design bureau I never once saw rocket take off. I have watched the event on television and in the cinema screen many times but never once in reality. Never in Batkour. So the first rocket and spacecraft prepared for the launch I ever managed to get near was meant for me. As an engineer who works on space technology, I am a bit sorry for the rocket. My take-off required its 'destruction', for when all the fuel is consumed, three of its stages have to submit to Earth's gravity, thus giving life to only a small vehicle. But there was no time to lose and I wanted that day to come as soon as possible.

At last the morning came, and every single minute had been scheduled. We got up and had our last wash on land. According to the established custom I signed my name and wrote the date on the door of my hotel room with a soft-tip pen. Yuri Romanenko was busily doing the same nearby. His third flight was thus marked by a third autograph. We got on the bus to take us to the launch pad.

After that an invisible mechanism seemed to have been put into operation. A quick breakfast, the space-suits, and the report to the Chairman of the State Commission K. Kerimov on preparedness for the flight. Then back on the bus and the meeting with the Chief Designer, who was already at the foot of the rocket. The only thing he asked us for was a quick report as soon as we took our

seats in the spaceship. The weather was awful. Rain and snow were turning into ice. It was particularly hard to work at the gantry. People had already been working for many hours, and their sheep-skin coats did not help against cold. Our report would be the sign for them to leave the launch pad. That was why as soon as I put my head into the craft, I instantly established communication and reported that we were in the spaceship, even though Yuri was still on the landing near the lift. Eventually he took the next seat and we parted with our two comrades, who were busy locking the hatch from outside. Thus, we remained all by ourselves.

The launch must have been so routine that I first realized I was in space only when a Russian doll 'Matryoshka' swam up before my eyes. This meant weightlessness, and I got used to it in practically no time. Two days passed and we docked with the station to form the "Soyuz-2"- "Mir" orbital complex.

We had many things to do. During the first month and a half the complex received three "Progress" transport vehicles and we started preparing for the important event—docking with the "Kvant" module which was scheduled for April 5.

The "Kvant's" orbit was corrected from the Earth. We watched it approach the station from a television camera near the docking hatch. When the "Kvant" was 400 metres away, ground control instructed us to take our seats in the descent module and shut the tunnel hatches. This was always done in case of emergency so that if, for instance, a faulty docking procedure between the "Kvant" and the "Mir" station caused depressurization, we could return to Earth in our own spaceship.

We took our seats and waited. This docking would open up a new stage in our space activity. The fact was that "Kvant" had a new control system based on gyrodynes (huge driven flywheels) which help to conduct orientation of the orbital complex very accurately. If before it had been necessary to start the orientation engines to get even a small change in position, now there was no need to waste fuel—everything was being done by the gyrodyne's energy. This was required by the planned research. For example, the ultra-violet telescopes on the "Kvant" had to be pointed at particular parts of the sky.

There was much work ahead and we waited for the docking impatiently.

When "Kvant" was only 100 metres away from us, the Earth unexpectedly told us that the module was departing from the station. Yuri and I immediately rushed into the tunnel hatch and saw through the windows that some 50-60 metres away, sparkling in the Sun, the "Kvant" had passed us by. Clearly a parameter of approach was wrong: speed, or the mutual position of the two crafts. In cases like these the automatic control sets the drift system into operation. First the module moves away from the station and then passes it by.

Of course, Yuri and I were very anxious. Everyone has a particularly keen reaction to failure in space, but at that time we could not even imagine how severely we would be tested in the next few days.

It took the Flight Control Centre four days to reproject "Kvant" into our orbit. This time contact was made fairly well. Yuri and I were very happy indeed, now, we thought, the docking would begin and the hatches would open. We congratulated each other on the successful completion of the docking. But there was no cause for rejoicing. We heard from the Centre that the docking rod did not reach its goal and had not linked the objects: there was some kind of obstacle. We began to examine the unit through the small windows and saw that a piece of wire was sticking out. We reported this to Earth, and they started thinking over the wire problem. It was possible that it had been driven into the screw mechanism of the rod and jammed it. In ground control they analyzed a number of possible explanations.

While they were studying the situation on the Earth, we conducted our own 'investigation', and although it was not very clear to us what could have happened, we decided that a space walk would be essential.

After a short pause Earth again contacted us. Valeri Ryumin, the flight commander, was at the microphone, but we started to speak first. Yuri Romanenko asked: "Valera, when?" After a little while we heard: "Probably in two days. If you can be prepared by then." The words 'space walk' were not even pronounced, but we nevertheless understood the purport of his message. We all shared the same thought.

In general four days are required to prepare for a space walk: the space-suits must be got out, checked, provisioned with water and oxygen, trained for extraordinary situations, and so on. But we did not have time for all that. We had only two days because the power supply in the "Kvant" was running down, since its solar batteries were not pointed at the Sun.

The few hours for preparation were cut further by Ryumin. He said quite explicitly: "Sorry, boys, two days won't do. You'll have to speed up." Presumably the situation was getting critical. Romanenko, who had a great deal of experience of working in open space, having first walked in space with Georgi Grechko, by going out through the station's dock hatch, and then working at the Flight Control Centre on the space walks carried out by Vladimir Solovyev, Leonid Kizim, Alexandr Alexandrov and Vladimir Lyakhov, said to me: "I'll take care of the space-suits, and you prepare the tools we have at the station." Unfortunately, I had practically nothing to do, since the basic tools were to arrive on the "Kvant".

I tied together the screw-drivers, a hammer, a pair of ordinary scissors, and a pair of pliers with a piece of cord and put them into a bag lest they should fly away, while by that time Yuri had prepared the space-suits. We were ready to leave our vehicle. Ground control had suggested that first we simply examine the docking units, return to the station and then perhaps on the following day do another space walk. This presupposed that after consulting Earth all that had to be done could be done properly.

We put on our space-suits, checked them, depressurized the compartment, opened the hatch, and found our way into space.

According to the instructions, I was the first to leave the station. Yuri Romanenko swam after me. I had already got hold of the strap near the hatch when I heard an awful pop in my ears: the pressure in the space-suit had started to drop. It crossed my mind that my glove must have become unbuttoned. If so, the situation was hopeless. I only informed ground control that my pressure was dropping. Probably they could see for themselves by telemetry. A horrible silence came over the Flight Control Centre. Seconds past. I heard Vladimir Solovyev

say: "Quick. The emergency supply of oxygen. Switch on the injector." I did so but the pressure kept dropping only a little more slowly. At that moment Yuri Romanenko turned me round and began examining my space-suit. He suddenly changed over the pressure transfer knob. He had seen that it was not in the proper position. In one direction the pressure in the space-suit was normal and it is inflated. This is fine for the normal work, but when something exceptionally subtle has to be done the pressure can be reduced to half, but only for a few minutes. When I left the vehicle I must have touched the switch and lost some of pressure in the space-suit. I could hardly imagine that this particular episode was being televised and that my mother would see it with her own eyes and calm down only after a telephone call from the Flight Control Centre.

When I was sure that everything was all right, I said to Yuri: "Now, let's go on". We began moving towards "Kvant".

We were supposed to check the docking units, but it was first necessary to separate the "Mir" from the "Kvant", which was done according to the instructions from Earth. We came up to the place of their docking. Yuri suggested that we should try to remove the "Kvant" still aside with our hands only. We tried and gradually the orbital module started to turn. It was an unusual, whimsical sight quite beyond the standards we have on Earth. There we were manhandling a huge thing weighing twenty tonnes without any effort!

Then we examined the station's docking unit. It was clear at a glance that a rubbish bag had got into it. There was no time for any emotional reaction. As soon as we possibly could we removed the rubbish from the docking unit and when radio contact was established we reported to Earth that it was possible to resume the docking. Before letting automatics take control, we pulled the "Kvant" back to the station into its former position.

We watched the docking standing on the edge of the complex. We heard the operator count down: 400 millimetres, three hundred, two hundred and seventy five... (This was when the failure occurred during the first docking.) Then two hundred, and finally docking. I think, everyone at the Flight Control Centre joined us in sigh

of relief at this moment. It was time to go back for we had been in open space for three and a half hours!

When we took off our space-suits we felt completely exhausted. Only later was it deduced how the internal rubbish bag had got into the docking unit. When the last "Progress" transport spaceship was being unloaded we had to open the hatch several times. Quite imperceptibly air currents had pulled this bag into the cone of the station's receptacle, as if it were some kind of quiet backwater. However, the deduction came later, but even in the first minutes after we returned to the station from open space we were certain the flight would continue. In the evening I took up my guitar, which accompanied us in the flight, and Yuri and I finished that very hard day by singing a wonderful song which I had often heard my father sing. It was the anthem of the Fifth Aviation Regiment of Guards.

The Launch Throughout the Years

This song was sung by my father's companions-in-arms who used to get together at our place quite often. Those were exceptionally interesting evenings for my brother and me. The pilots always talked about war. From what we heard it gave us the impression of something very cruel rather than a series of romantic adventures. Well, they spoke of what they had actually seen. At the time I was struck by the words they would persistently repeat, only real difficulties and tests could reveal what kind of man you are. I also remembered one particular episode that took place during the war.

An inspector from the headquarters arrived at where their regiment was stationed. It was 1942 a very difficult year, but none had stopped inspection. The inspector decided to check on the combat proficiency of the regiment's pilots.

They took off at dawn to cover bombers and in less than twenty minutes the two squadrons were 'face to face' with enemy fighters. There were more of them and the encounter was bitter. The inspector, who did not fly regularly, found it unbearable. He simply chickened out. In short, he retreated, got himself in the clouds and lost his way altogether since he did not know the locality.

When his fuel ran out, he landed in some forest glade, and since he knew he would be in for trouble, he decided to burn his plane as if he had been shot down.

He returned to the regiment late in the afternoon, carrying his open parachute. He then ordered the pilots to line up and started to lecture them on how they as guards should be ashamed of themselves because they had deserted their commander. (He was senior in rank and considered himself their commander.) He continued to scold them, pointing at his parachute all the time. Meanwhile one of the technicians examined the parachute very quietly, and saw that although the canopy had been pulled out, all the shroud lines remained in loops as stored. In other words, the inspector had pulled rip chord, the silk had come out, but the shroud lines still remained carefully folded. The technician then addressed the inspector in a voice that could be heard by everyone: "Comrade Colonel, how could you have jumped and yet the shroud lines remain in their stowage loops?" This apology for an inspector was thus unmasked, he was degraded to the ranks and sent to the front. The pilots had not sympathy for the colonel. They could not forgive poltroonery and were very strict with each other.

In 1943 my father was made a Hero of the Soviet Union. He continued to fly after the war and we moved from garrison to garrison with him. We were in Sakhalin, in the North and I spent all my free time at the airfields, watching the pilots work. What they did was interesting, but very difficult. Undoubtedly, I wanted to be like my father.

However, after leaving school I could not leave home and so I entered the Bauman Higher Technical School in Moscow, even though I really wanted to attend a school for pilots. My only consolation was that two graduates of the Bauman Higher Technical School, Alexei Yeliseev and Konstantin Feoktistov, had already been in outer space. This meant that I also had a chance.

When we were being assigned work in the fifth year I asked to be sent to S.P. Korolev's design bureau. That was how I found myself in that renowned group of designers, working as an engineer responsible for the strength of constructions. For twelve years I spent several hours a day commuting to the office and back. I managed to get

some sleep on the bus and read books in the underground so as not to lose time.

What did I do in the design bureau? Well, I calculated the strength of small and large tubes, which space technology uses an infinite number. We were particularly concerned about the loads which act upon the vehicle in the very strenuous periods, e.g. during the launch and landing. The "Soyuz-T" was my work too. I remember, when I came to the design bureau, the "Soyuz" series was still being launched into space. To participate in the design of a new spaceship, about which only a selected few knew, made me especially proud.

In 1975 I, like many of the other young engineers at the design bureau, applied to be considered for cosmonaut training. I was not refused. First I passed the medical commission. It was quite easy. For instance, they only rejected people with poor eyesight or hearing. Since that was the main parameter, I was accepted and they sent me for a stationary check-up at the Institute for Medical and Biological Problems of the USSR Health Ministry. The tests there were much more severe, and I failed. However, so not to put a cross against career in space I had my tonsils taken out.

Only then was I allowed to take the entrance examinations. There were twelve candidates in our group and after a certain amount of training we were to take examinations in all the systems of the "Soyuz-T" spaceship.

We took examinations for a whole year. For instance, to take the exam on the propulsion system, the first thing you saw was a big table at which twenty leading authorities in the field were sitting. We sat in front of them and had to answer their questions off the cuff. You may be given ten, fifteen, twenty, or more questions, nor was the time limited. Only at the end were you given a mark.

I must say that our knowledge was assessed very rigorously indeed. Often someone doesn't know much about spaceship systems but understands how they function, and this becomes quite obvious when he starts answering the questions. Clearly after further training he will acquire the necessary experience and skill. For instance, Musa Manarov could grasp everything at once and received high marks without making much effort.

The other way round was also possible. Someone can

learn everything by heart, but it is easy to see he won't be able to cope with the work since he cannot handle the information he knows. In cases like these there is no hope of a good mark.

At last our year's session came to an end and we were summoned by Valery Kubasov. A list of candidates was prepared according to the marks we had received. Those who had obtained the best marks sat in the front row; the less fortunate behind. Kubasov started to read the list very slowly. I think the first name on the list was Vladimir Solovyev, then came Viktor Savinykh. They were about five years older than the rest of the group, and were certainly more experienced and knew more than we did. Musa Manarov was next. Then came Alexandr Serebrov. I discovered I was fifth and started waiting for Kubasov to tell us how many people would be enrolled in the group. Kubasov paused for a long time and gave his final verdict: "We shall enrol seven people."

We had a fairly successful 'group of seven'. All but one of us have now been in space, and I think that the last one will also leave his autograph at the hotel for cosmonauts. The seven then went on with the training, the chances of the other five people to become cosmonauts now being nil.

Months of training followed. Some of our 'group of seven' were sent to the 'long-term' orbital stations ("Salyut-6" and "Salyut-7"), while Musa Manarov and I, as the youngest candidates, were assigned to work on equipment that was still in the plan-stage. We did a lot of work with the designers, and travelled from one factory to another all over the Soviet Union. It was a real schooling indeed. At last we were included in the group preparing for a mission to the "Mir" station. After many lectures, classes, and the final exams, the crew was chosen. The flight crew consisted of Vladimir Titov and Alexandr Serebrov, while Yuri Romanenko and I formed the alternate crew.

I remember that I discovered my commander was Romanenko only on the eve of a joint training, which had to take place beyond the Arctic Circle. So we actually met on the plane. Although I knew quite a lot about him since he had already been on two space expeditions, he knew nothing about me.

We were immediately confronted with very harsh

training conditions. We had to remain twenty four hours in the barren tundra and only use the resources cosmonauts returning from a mission would have. We gradually handled one thing after another: the flare pistols and the knives. Using an adze we cut snow bricks and built an igloo. We also used different ways of getting water from the snow, either by making a fire or by heating a flask with our bodies. We got through the training session quite well. I liked Yuri because he was very considerate, and although very experienced, he never tried to force anything upon me. He simply instructed me by his own example. We had to travel a lot after that, to Baikonur, as well as to Yerevan and Kiev where they were developing the research instruments.

We prepared for the flight as the alternate crew. However some weeks before the launch, and only a few days before Vladimir Titov and Alexandr Serebrov were to leave for Baikonur, it was decided that our crews should change places. Romanenko and I went to the cosmodrome as members of the flight crew.

Yuri and I had wanted the others to remain the flight crew, indeed. Romanenko was quite adamant about it. During our two years of training together he never once said that we could fly before the others. Quite the contrary, he invariably let Vladimir and Alexandr train first so that we would come afterwards. He constantly told me: "When they take off, we shall continue preparation for a flight. By that time the scientists will have developed new experiments, and our programme will be much more complicated."

When the decision became irrevocable, we were very sorry for the boys. People tried to explain that it had been fate. We were particularly sorry for Vladimir Titov. It was another failure. During his first mission his spaceship failed to dock with the station, while during his second, the launch rocket caught fire and the cosmonauts were saved only by the escape system.

Failures often make one despondent. Once I had been recalled from a programme. I was to have gone on a visiting expedition and even though the crew had begun training for it, it was broken off because the commander Yuri Malyshev was to prepare for the Soviet-Indian flight. I didn't know in which group I was, in which

vehicle or with whom. Many cosmonauts have experienced moments like these.

When you are told that you have been taken off a programme life does not seem worth living for the first minutes and hours and you have no wish to do anything at all. In due course the frustration wears off, and you start preparing for another mission, leaving miseries behind. Time is a great healer! More importantly a person who has experienced such trials becomes morally and psychologically hardened. Musa Manarov had also been recalled from a programme and yet his morale remained good and he eventually attained his goal. A cosmonaut's path is seldom strewn with roses. You don't simply join a group and immediately fly into space. Usually quite the opposite happens and the preparation takes time.

It took eleven years before I went on a mission. Clearly you must have moral support at home, and credit must be given to the wives of cosmonauts, whose understanding must be praised.

For instance, for the last two years I have lived in Star City, whereas my family had to remain in Moscow, and our home was in a district from which it was practically impossible to commute to the Training Centre every day. I used to return home on Saturdays, and early on Monday mornings I had to be making my way back to the Centre. My wife never failed to support me morally.

Later, during all the trials during my mission the faith in my family gave me extra strength.

Why Do We Need the Space?

I have frequently heard laymen say that space-flights are a waste of time and money and that we could do very well without them.

What practical tasks Yuri Romanenko and I did during our expedition.

Let me begin with the "Kvant". After the docking we began to work on its degreasing. The apparatus was not only produced in the USSR, but also in Great Britain, the FRG, Holland, and the European Space Agency. It was actually a unique space observatory. Twice a day we corrected the orbital complex so that the X-ray

telescopes could carry on the observations of the most mysterious parts of the starry sky. It turned out later that those observations provided the scientists with priceless data about the supernova that appeared in the Magellanic cloud in February 1987.

X-ray investigations are practically impossible on Earth since the planet's atmosphere absorbs more of the radiation. Thus, an orbital observatory is practically the only way to plumb many of the mysteries of the remote universe, and also of the nearer space, or the planets of the Solar system, and the Sun itself, which affects many processes taking place on Earth.

But besides the Universe, we were also concerned with our own planet. We carefully observed the atmosphere, and photographed the surface. Now the new "Sever" cameras are installed on the station. They are handy, compact, and they can easily be installed at any of the windows to work automatically. We were using hand cameras, and also took two pictures, one with the wide-angle lens to cover a large area and the second one with a narrow-angle lens to single out a region or city. The camera had filters so that the surface was photographed in particular wavelengths. After interpreting these photographs, scientists can determine the rocks, both on and below the Earth's surface, and assess mineral resources. We took many such pictures returning over a hundred films to Earth. They all went to the "Priroda" (Nature) State Centre where they are being analyzed by geologists, and soil scientists, botanists, and climatologists. I think a vast amount of money would have been required to make the same observations on such a scale using Earth-based technology.

A feature of our mission was the development of new technologies on a semi-industrial level. For instance, we worked on the "Svetlana" and "Ruchei" electrophoretic installations. They yielded super-pure proteins. The visiting expedition later 'took' them down to Earth, where they were immediately applied in practice. Some of our 'space biological produce' became the starting stock for the manufacture of fodder proteins, while the rest was impatiently awaited by medical scientists for the creation of new medicines.

The "Korund" installation yielded super-pure semi-

conductors that cannot be made under terrestrial conditions. All this was achieved on a semi-industrial level, i.e. the materials were employed industrially on our return from orbit.

All in all we performed over five hundred experiments during our mission, and there is little doubt that enormous profit can be derived from space.

In order to cope with everything in orbit we had to plan every minute of our time. This included time for research, physical exercise, meals, and recreation.

Most of the free time (it was usually after eight in the evening), Yuri and I would listen to music, Vladimir Vysotsky or Yuri Vizbor, and sometimes we played the guitar (I taught Yuri to play it at the station; I have been playing the guitar since school). Sometimes we had tea together (we had special tea bags) and whiled away our time talking about mundane problems. When either of us wanted to be alone we would retire to our cabins and write letters to Earth.

Generally speaking, I think the "Mir" station had one deficiency in its design. It lacked a shower, although the previous "Salyuts" had it. The Flight Control Centre assured us that the next expedition would have one, but that was not much consolation to us! Romanenko soothed me by saying that there was no danger in being unwashed for a year. He found an alternative. After the exercises we would have a flannel wash with a towel soaked in hot water and shampoo. Then came a cold water towel, followed by a dry towel.

In July we were joined by the Soviet-Syrian crew to bring the crew to five on board. I remember how the Syrian cosmonaut Faris saw his own country from orbit for the first time. He was simply enraptured. There were no clouds and Syria presented itself in all its beauty.

It was not difficult to find it. Cyprus seemed to point it out to us. Damascus, situated on an elevation, was also clearly visible; it must be the biggest city in the region. We could easily discern Beirut close by. There was fighting there and we watched the fires raging in that city. We also saw oil fires in the Persian Gulf and damaged tankers with long black oil trails in their wake. From space the region really looked like a 'hot bed' on the planet. It was bitter to see it all.

Yuri Romanenko was experienced at organizing work aboard a space station and he deftly distributed duties among the crew. We had no problems in carrying out the experiments, which made us free by five or six o'clock in the evening (in spite of the fact that the Soviet-Syrian mission had its own unique and integrated investigations). Thus, we had enough time to complete the symbolic activities. What I have in mind here is that it was necessary to 'stamp' postal envelopes, prepare souvenirs for return to the Earth, have our group picture, and do television reporting. Television took a lot of our time and broadcasts were made to Syria, our own country, and the whole world. So we had to prepare for them properly: get out flags, pictures of the leaders of the two countries, and place gifts and souvenirs on the table.

The week the international crew was on board passed quickly. The departure day was exceptionally sad for me, I had to curtail my work at the station, part with my commander and return to the Earth.

The physicians had decided to bring me home several weeks before our guests arrived. They had found that my heart activity was not reacting normally to physical loadings. I didn't even feel it myself. I regularly made tests, underwent all kind of investigations, and felt quite well, but my fate was decided on Earth.

Vladimir Solovyev informed me of my return. He was brief. Immediately after him I heard Academician O.G. Gazenko, the Director of the Institute for Medical and Biological Problems of the USSR Health Ministry. He explained the situation in detail, mentioning the possible causes for the deviations in my cardiac activity and added that there was nothing very serious. However, since the flight was to continue for nearly another half a year, it was better for me to return to the Earth to avoid risking my health. Alexandr Alexandrov would replace me. Yuri and I tried our best to persuade him to change his mind but Gazenko remained adamant. Yuri Romanenko could only request that my case be very thoroughly investigated and not to let my 'premature landing' affect my professional career. Gazenko promised to see to it that everything was done objectively.

When it was clear there was nothing to be done, I started preparing to land. I certainly looked forward to the

remainder of the mission since I had some very interesting ideas and some of the experiments had been prepared.

It was a very difficult period in my life. I couldn't imagine how I would go on living and how I would meet my friends. Yuri comforted me and said that nothing terrible had happened and that I had actually fulfilled my programme. In the long run understanding the reason for my heart dysfunction was important not only for me, but also for everyone who would take part in long-term expedition. We could have come across a new and previously unknown phenomenon. I remember that when parting with Yuri before the undocking he looked at me and said: "Judging by your face, you don't seem to be suffering from any cardiac disease at all." I have always remembered these words.

After the landing I spent several days at the Baikonur cosmodrome. Then I underwent a more thorough analysis at the Medical Centre. My wife and son were only allowed to see me on Sundays.

The district along the Pyatnitsky Highway outside Moscow abounds in beautiful places. I often went for long walks in the forest with my doctor Ivan Reznikov. We gathered mushrooms, talked about this and that, and I gradually recovered.

After the medical tests it was clear that I would remain a cosmonaut.

TO THE READER

Mir Publishers would be grateful for your comments on the content, translation and design of this book. We would also be pleased to receive any other suggestions you may wish to make.

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MY LIFELONG ROAD TO LIGHT

L. Levshin

Although science has been enriched by very many scientists, few have created new disciplines. This is because not just scientific achievement is required, so too is originality of thought and an ability to point the way to the scientific community.

Sergei Vavilov (1891-1951) was one such scientist. Indeed, the value of his efforts in the administration of science means that he must be honoured as a father of Soviet physics. As a mark of respect for his work and his years as president of the USSR Academy of Sciences, the Institute of Physical Problems was named after him.

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This biography will bring to the attention of non-Russian speaking readers the life and work of an outstanding physicist, about whom there is certainly very little other information in English.

AKSEL BERG, A MAN OF THE 20TH CENTURY

I. Radunskaya

This is the life story of a man whose activities in the Soviet science were extremely creative and fruitful, who lived a fantastically interesting life. Aksel Berg was an outstanding figure in the Soviet science, Member of the USSR Academy of Sciences, Admiral of the Soviet Navy, Deputy Minister of Defence. He was lucky to be among the founders and organizers of many new branches of science in the USSR, such as radioelectronics, radar engineering, radionavigation, computer engineering, etc. In his later years, he did much for establishing the Soviet school of cybernetics.

NIKOLAI ZHUKOVSKY

A. Kosmodemyansky

A great Russian scientist, Nikolai Egorovich Zhukovsky (1847-1921), affectionately nicknamed the «Father of Russian aviation», was the founder of theoretical, technological and experimental air-flow mechanics. Professor at Moscow University and the Moscow Higher Technical School. His outstanding discoveries, the research techniques and procedures he introduced to various branches of theoretical and applied mechanics, the promising vistas he opened for research left an indelible trace in the history of science.

On January 16, 1911, addressing the audience that gathered at the Polytechnical Museum in Moscow to celebrate his birthday, Zhukovsky said: "When a man has travelled the major part of his life-road his mind wanders back to ponder the content of his life. My main interests have focussed on my favorite science—mechanics". In this book the author concentrates on Zhukovsky's work in aerodynamics and the theory of flight and also discusses in brief his other studies in theoretical and applied mechanics.

Outstanding Soviet Scientists

At a time when attention is being paid to the Soviet Union's current and continuing space programme and its peaceable utilization of space, this anthology is appearing at an appropriate moment. It has been compiled from essays written for the weekly newspaper *Sovetskaya Rossiya* (Soviet Russia) about and by the personalities involved in the Soviet space programme. The subjects covered by the essays are quite diverse from memoirs, biographical notes, and letters to a medical account of the influence of space on human beings, an essay on how humanity can exploit space, and what happens when things go wrong. Finally, there is a photographic essay about our voyage to the Universe up to the launch of the massive Energiya rocket series.